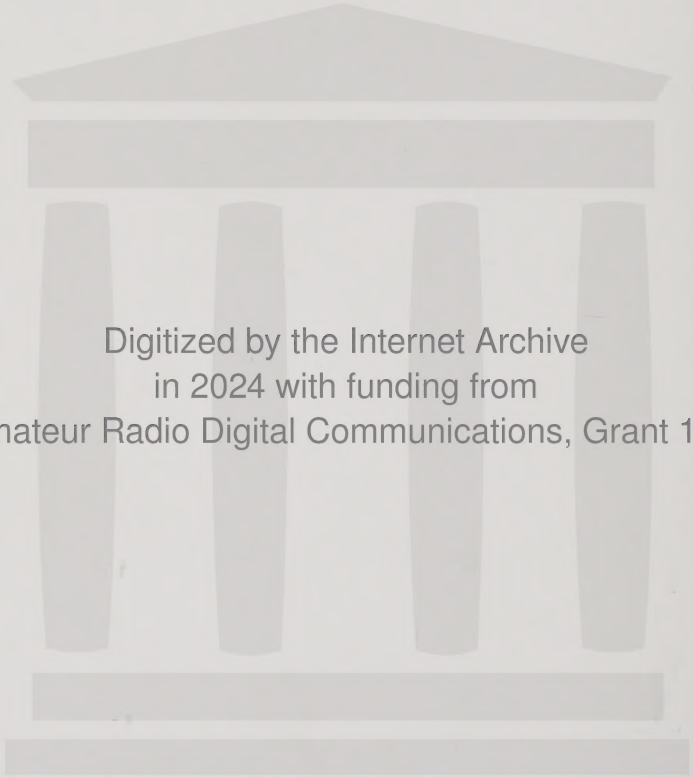
digital terrestrial television

broadcasting in Australia



digital terrestrial television broadcasting in Australia

FIRST REPORT ON THE WORK OF THE
AUSTRALIAN BROADCASTING AUTHORITY
SPECIALIST GROUP ON
DIGITAL TERRESTRIAL BROADCASTING

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foreword

While every effort has been made to use simple language in this paper, a number of technical terms and abbreviations must be used to communicate its message. To assist readers a glossary has been provided at Appendix 4 which explains the terms used and in some instances provides a simple tutorial to assist readers who may be unfamiliar with them.

introduction

Despite the prominence given in the general press to the inroads of cable in the USA or satellites in Europe, analog television, broadcast terrestrially in the VHF and UHF bands is still the major method of delivering video entertainment to the home. Virtually every household in the developed world is now equipped with a conventional analog television receiver using one of three colour television standards PAL[1], NTSC or SECAM. This technology has remained substantially unchanged since the 1930s.

[1] See glossary Appendix 4 for explanation of terms

Conventional television uses analog transmission, which means the signal level transmitted varies in accordance with the colour and brightness of the elements of the pictures. Any disturbance to this signal along the transmission path introduces false information that cannot be removed and so the received picture is of lower quality than that transmitted. In digital transmission the detailed information about the elements of the picture is converted to an 'on/off' code which contains extra data to identify false data (errors) in transmission and to allow the receiver to correct these errors. The receiver must simply detect whether the signal is 'on' or 'off' to extract the code and then check for errors and correct them. In this way, interference to the signal can be eliminated and the received picture can be a faithful replica of the original transmitted image. The major obstacle to digital transmission has been the difficulty in transmitting and processing the large volume of digital data needed to faithfully code a moving picture

During the past 30 years there have been major developments in digital techniques for the transmission, storage, and processing of images, sound, and data. Much of this has been made possible by advances in computing technology and in microcircuit design.

Today, digital technology is in everyday use in most television studios but it has not been technically feasible to transmit these digital signals over the air within the confines of existing channels.

Recent advances have allowed compression of digital image data to the extent that transmission over conventional channels is now possible.

Internationally, cable and satellite television delivery is rapidly moving towards full-scale digital transmission to end users. Digital delivery of television pictures over the conventional terrestrial over-the-air broadcast channels presents a greater challenge, but the major obstacles have already been overcome and mature digital terrestrial television broadcasting (DTTB) technology is expected to be implemented in the USA and in Europe well before the turn of the century.

A number of benefits will flow from the introduction of digital transmission technology for terrestrial broadcasting. DTTB will improve the quality of the picture displayed at the receiver by overcoming most of the transmission impairments common in analog systems (e.g. ghosting). It will provide the capacity for the delivery of more services within the same radiofrequency spectrum used for television delivery today. In addition, digital transmission can deliver high definition wide-screen images within the bandwidth currently occupied by an analog television channel. Because the transmission path is a digital data highway, that highway can be used for the carriage of a range of ancillary data services in parallel with the transmission of television pictures and sound.

Digital transmission for terrestrial broadcast will complement the other digital signal delivery options such as cable and satellite. It will open the way for a common family of standards which will open gateways to the 'information superhighway'. It will establish a foundation upon which future video entertainment and information services, not yet conceived, can be built. It is a technology that will take television broadcasting well into the 21st century.

Although satellite and cable television services are commencing to use digital transmission, the signals emerging from the set-top decoder box in the home remain in their traditional analog form. This is necessary because there are not yet any purpose built digital television receivers. DTTB is likely to introduce the first true digital receivers.

Australian engineers have been participating in international technology developments through committees of the International Telecommunications Union (ITU) and broadcasting unions since the late 1980s. Initially, joint technical studies were convened by the Federation of Australian Commercial Television Stations (FACTS) and involved Department of Transport and Communications (now the Department of Communications and the Arts), ABC and SBS engineers. At the formation of the Australian Broadcasting Authority (ABA) in 1992, it was evident that the ABA would need to be fully informed of the potential for digital television broadcasting in the Broadcasting Services Bands if it was to meet its planning obligations. A specialist group of experts was established, drawing resources from within the ABA, the Department of Transport and Communications, broadcasters, carriers and manufacturing interests. The terms of reference and composition of this group are at Appendix 1.

The Specialist Group set out some details of its preliminary consideration of the issues in a discussion paper *'Digital Terrestrial Television Broadcasting In Australia - Issues And Options'* released for public comment with appropriate advertising in the national press (see Appendix 2).

The Specialist Group has now considered the public contributions, completed further studies including monitoring of international developments and these have been submitted to the ABA for consideration. The ABA's preliminary views based on this advice are documented in this report on DTTB in Australia. While many questions as to the best choices for Australia remain unanswered, there is now sufficient information to engage a wider debate on policy issues that need to be settled so that the opportunities presented by DTTB technology can be fully exploited to benefit all Australians.

The preliminary views expressed in this paper are those of the ABA after consideration of the range of opinions presented in submissions and by the members of the specialist group. This paper is intended to stimulate further debate on these issues and further submissions from interested people are invited.

Submissions should be addressed to:

The Convenor
DTTB Specialist Group
Australian Broadcasting Authority
PO Box 34
BELCONNEN
ACT 2616
AUSTRALIA

Summary of Preliminary Views

Preliminary View 1

The substantial weight of opinion expressed in the public comments and within the Specialist Group, is that DTTB services introduced to Australia will need to have the flexibility to meet market demand. Premature restriction to specific technical quality or service targets may stifle the market driven development of the service. Broadcasters will need to experiment and react to their audience in a dynamic way to encourage the purchase of new receivers.

The ABA considers these arguments have merit but further information about technical developments, and market exploitation, is needed before any firm position can be developed on how multi-program versus HDTV issues should be addressed.

Preliminary View 2

The termination of existing PAL services assumes existing services must at some point migrate to DTTB. An arrangement to allow existing broadcasters to be allocated an appropriate DTTB channel and be able to

operate this channel in parallel with their existing channels would facilitate the introduction of DTTB.

The termination of existing PAL transmissions will depend largely on when DTTB services are introduced in Australia, the level of acceptance of DTTB services by the consumer and the penetration of new DTTB television receivers. Other factors such as cost to the broadcaster and consumer, quality, quantity and variety of entertainment services will be significant.

No actual time period or date can be fixed at this point in time for the termination of existing PAL services in Australia. After a decision is taken to launch DTTB in Australia, the termination date for PAL should be subject to regular review and the decision made in a consultative process by both industry and government organisations.

Preliminary View 3

Irrespective of what band is to ultimately be used for DTTB, DTTB should desirably commence in the band where it will permanently reside. This will ease the burden on consumers.

Further studies need to be undertaken to determine whether it would be possible to accommodate all potential services on UHF and for all DTTB services to commence on UHF while there is an incentive of adopting the new technology.

A mix of VHF Band III and UHF may be required to accommodate the demands for DTTB. Initial studies suggest DTTB could use VHF Band III in the capital cities but UHF will be required for DTTB in regional and country areas because of scarcity of VHF Band III channels.

Further studies need to be undertaken into the feasibility and cost of UHF options for DTTB both from the broadcaster and consumer perspective so that any decision on the appropriate band for DTTB will be fully informed of the costs and benefits.

Preliminary View 4

Considering the support for retention of 7 MHz channelling, using either the US system or a variation of the European system and the massive changes that would be necessary to existing television services to move to 8 MHz channel spacing, the ABA considers priority should be given to addressing how the candidate systems might most efficiently be accommodated within the existing frequency allotment plan.

The ABA shares the concern that, if it became necessary to develop a 7 MHz system specially for Australia, it could result in unduly expensive receivers and Australian viewers and broadcasters could suffer because of its lack of standardisation with the systems in use in other parts of the world.

Preliminary View 5

It is premature to make a choice of either system at present, particularly as there are signs of increasing convergence between the European and North American systems.

Further studies are necessary to define the specific characteristics of a system suitable for the Australian broadcasting environment.

Preliminary View 6

The choice of the DTTB standard need not be related to the standard adopted for satellite pay TV or other pay TV services that might be introduced in the near term. However there does appear to be longer term advantages for the consumer if all services converge to a common or compatible family of standards.

Preliminary View 7

Introduction of DTTB should not reduce the possibility for television broadcasters to tailor programs for local and regional audiences, and hence contribute to access and diversity. Single frequency network principles may have advantages in some aspects of planning, particularly for translators and for regional services, further consideration should be given to the application of such networks when DTTB developments are further advanced. The ABA notes that single frequency network arrangements have at this stage only been demonstrated with the use of the COFDM type of transmission system.

Preliminary View 8

It is premature to reach any conclusions at this time on when it may be feasible to commence DTTB, but there will be much better information on which judgements can be made within the next 12 months.

DTTB Technology - State of Play

International Developments in DTTB

For decades television engineers have striven to deliver the picture quality they have been able to generate in the studios to the home viewer. Their efforts have been hampered by the inherent limitations of the analog delivery system. Now, with digital video technology it is possible to realise this ambition.

Through the decades which followed the spread of television broadcasting following the Second World War 1939-1945, television broadcasters took advantage of every technological break-through in electronics to move their industry from one which only 'just worked' in the 50s and 60s to one which was technically mature by the 1980s.

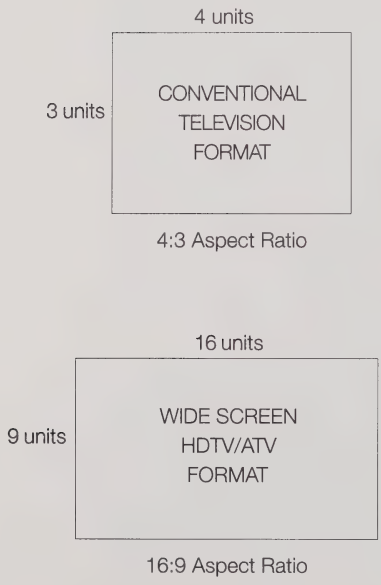
In the early 1980s the need for continual improvement in technology to develop the broadcasting service had dissipated. The equipment in the studios was largely satisfying production requirements, the transmission facilities were reliable and, significantly, the home receivers were providing adequate quality and long life. With this growing stability consumer equip-

ment suppliers began searching for ways in which to stimulate a market for new television sets.

Enter HDTV

During the early 1980s, the International Telecommunications Union Radio-communications (ITU-R) Study Group 11, responsible for television matters, developed objectives for a new generation television system. This system was required to provide for wide aspect ratio (16:9) pictures, with at least double the resolution of existing television services, with screen sizes of approximately 1 metre diagonal. The resultant service was intended to approach the viewing experience offered by 35mm film in the cinema.

Figure 1. Aspect Ratio of Television Pictures



The first practical proposal came from Japan in the form of a simple extension of the 525-line NTSC system used in Japan and elsewhere. The Japanese proposal initially received support from the USA but was not accepted by the international community. It prompted the early announcement of a similar proposal from Europe based on an analog extension of the 625-line system (D2-MAC). Both systems depended on analog processing to reduce the band-width of the high definition studio signals to that capable of being delivered with existing satellite systems. The result of this was that while still pictures could be reproduced at the full studio resolution, moving pictures could only be reproduced with the resolution of existing systems.

With the great success of the Japanese as supplier of television receivers to world markets, it was neither surprising to find Japan leading the drive for high definition television (HDTV) nor to see the Europeans concerned that Japan might gain an unbeatable lead into the potentially lucrative new market. Both saw a need for HDTV based on analog technology to have a greater band-width than was available on existing terrestrial broadcast and cable channels. The spectrum used for broadcasting was crowded with existing

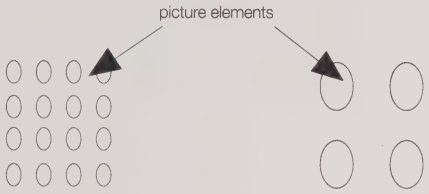
services to home receivers, which in all markets represent an enormous investment by the public. Any new innovation had therefore, to ensure that established public access to popular television broadcasting would not be disrupted.

Waiting in the wings were the satellite broadcasting plans developed by the ITU in 1977 and 1983. To establish a market for the new HDTV style receivers, the Japanese and Europeans chose what seemed the fastest route, satellite broadcasting. This immediately provided the wider channel bandwidth needed to carry analog HDTV broadcasting signals to the viewer. To some extent, because of the need for a new transmission means (satellite), and because of a perception that HDTV was a different business to conventional television broadcasting, neither the European HD-MAC project nor the Japanese MUSE made provision for existing broadcasters to move into the new world of HDTV.

The Move to Digital

In the mid 1980s the continual expansion of the telecommunications business had encouraged research into optical fibre as a method for carrying communications. This medium promised enormous increase in capacity but needed digital technology to reach its full potential. The computer industry was also expanding rapidly as a result of improvements in materials technology. This allowed larger integrated circuit chips for processing and electronic memory to be manufactured with increasing levels of capability at lower and lower cost. Both the computer and telecommunications industries were heading towards capacities

Figure 2. Resolution of a Television Picture



Higher Resolution = Finer more closely spaced picture elements

large enough to handle video images routinely.

By the end of the 1980s technology had reached a point where the computer industry was moving ahead with faster and larger data handling capacity and digital computers were increasingly penetrating the mass consumer market. The carriers were well advanced in their optical fibre ambitions and could see delivery of television as a major growth area which could generate considerable new business for their transmission capacity. Research by industries had shown that digital compression of video was feasible and would facilitate early entry to the video market. A co-operative industry development by the Joint Photographic Experts Group (JPEG) of the International

Electrotechnical Commission/ International Standards Organisation (IEC/ISO) developed a new industry standard for compressing a digitised image for storage on disk, known as the JPEG standard.

This work was followed by efforts to establish new standards for storing digitised moving pictures in a digital format. The Moving Pictures Experts Group (MPEG) first prepared a standard for video of moderate quality known as the MPEG-1 standard. It has since developed a family of higher quality standards including high definition television known as the MPEG-2 standard. (See Appendix 5 for an explanation of MPEG technology).

The breakthrough that is likely to be seen by future generations as the turning point in shaping the television business of the next century was a decision by the Federal Communications Commission (FCC) in the USA to encourage broadcasting of HDTV[2] in the existing broadcasting bands. Starting later than Europe and Japan, the USA saw the potential to revitalise its home consumer electronics industry on the back of a terrestrially based HDTV broadcasting initiative. In the same way as broadcasters were permitted to participate in the move from black and white television to colour, they were given the opportunity to participate in the television of the future.

Through 1991 and 1992 the FCC in the USA refined its terrestrial HDTV strategy which contained the following elements.

- An advanced television standard to be chosen from contending applicant proposals.
- A requirement for the system to co-exist with existing television services and use the channel capacity within the existing bands which could not be used by existing analog NTSC services because of limitations inherent in the installed receiver population.
- The allocation of these 'new' television channels, in the broadcasting band, would initially be to existing broadcasters for the broadcast of the new ATV standard.
- Existing broadcasters to have two years to apply for the paired television channel and three years to construct the ATV facility.
- Broadcasters to be required to surrender one of the two channels once ATV becomes the prevalent medium. This is now proposed to be in 15 years from the declaration of the ATV standard.
- After a set period broadcasters to be required to 'simulcast' the same program on both the NTSC channel and the ATV channel for 100% of the time. Proposed to be four years after the application/construction period.

2 The USA coined the term Advanced Television (ATV) for this initiative because it saw the system as offering a range of service possibilities which ranged from resolutions lower than that provided by traditional broadcasting through to HDTV.

Proposed legislative changes, designed to provide greater freedom to broadcasters in their use of the new channels, have encountered opposition. Strong expectations remain that US broadcasters will be permitted to offer multiple programming or other broadcast related services, in addition to, or in place of HDTV for some or all of the time.

In 1993 the FCC tested six candidate systems for their ATV standard and were unable to determine clear advantages between five of those tested, all digital. Subsequently all the parties involved with those systems forged an alliance (called the Grand Alliance) to develop a composite system. Most of the parameters are now agreed and the comprehensive full system testing is now underway.

As the USA has moved rapidly into the field of new television systems, the scene in Europe has also changed. The previously unheralded work on digital compression in that part of the world is now receiving full attention through the European Digital Video Broadcasting (DVB) project. The Europeans have largely abandoned the HD-MAC program and are quickly developing a set of digital television standards covering all main forms of delivery; satellite, cable and terrestrial.

The DVB project brings together some 130 organisations from across Europe. Its objective is to bring about consensus on the systems that will be used for digital television broadcasting in the years ahead. The DVB project is seeking to develop a family of systems for satellite, cable terrestrial transmission and telecommunications networks which will use as much common technology as possible.

A digital satellite broadcasting system has been developed which is suitable for use with any European satellite transponder, current or planned. A matching cable system has been developed in parallel. The development of a digital terrestrial system is under way, and the relationship between broadcast and telecommunications network delivery systems are under study. The system provides for a flexible range of picture qualities, together with adaptable multi-channel digital sound systems that can be modified to suit specific service-provider's needs.

Europe, USA and Japan have all been participants in the digital compression standards activities for MPEG. Similarly, representatives from all three have been co-operating in the optical fibre development programs co-ordinated by the ITU. The degree of co-operation in broadcast development has been severely curtailed by the competing ambitions of Japan and Europe to develop the analog HDTV systems. This has held back the attempts in the ITU-R to reach agreement on all of the parameters that would provide for single world-

wide standard of closely linked family of standards for HDTV systems.

In the November 1991 meetings of the ITU-R Study Group 11, largely because of an Australian initiative, a special Task Group (TG11/3) was established to look at pulling together a world standardisation of digital terrestrial television. That group had its first meeting in December 1992. The time-wasting arguments of the analog HDTV debates have been left behind and the broadcasting engineers are now working co-operatively to develop digital standards which will carry broadcasters digitally into the next century.

The DTTB System

The DTTB system comprises several elements:

- coding of the picture and associated sound into a compressed digital data stream.
- packaging the data in a way which will be sufficiently robust to allow it to be transported via cable, satellite, or terrestrial broadcast (this packaging involves organising the data into appropriately sized transmission packages and adding error correction and other data).
- transport of the packaged data via the chosen medium.
- reception, unpackaging, decoding and display of the images and sound at the receiver.

Each transport medium has different characteristics and consequently different transmission schemes are needed. There is now a high degree of international agreement about the way to code pictures and sound at the source. MPEG-2 is now the preferred system for most applications. MPEG-2 also provides a transport package method which has wide support. There is less agreement about the actual transport scheme. Various types of modulation scheme have been proposed but for terrestrial broadcasting only two remain under active consideration. North America is moving to standardise on a single carrier system known as vestigal sideband (VSB) but may still consider an alternative multi-carrier option known as orthogonal frequency division multiplex (OFDM). The Europeans have decided on OFDM and there appears to be support for that method in Japan. Discussion of these systems is beyond the scope of this report. It is sufficient for our purposes to understand that these are different ways of transporting digital data from transmitter to receiver.

International DTTB Developments.

United States of America

The successful demonstration, during the 1993 comparative trials for ATV/HDTV, of digital compression and transmission techniques suitable for use within existing terrestrial television channel bandwidth, effectively

eliminated analog systems from further consideration. The trials however, did not lead to the selection of a single 'best' system. This difficulty was overcome by the decision of the proponents to form an alliance (the Grand Alliance) to work together to develop a single system for the ATV in the USA.

A detailed system in the form of a draft United States Advanced Television Systems Committee (ATSC) Digital Television Standard has been developed and, while still incomplete in some aspects, reflects a high degree of consensus amongst the participants. The standard cannot be finalised until current laboratory and field testing is completed. The ATSC hopes that the FCC may be able to propose a HDTV standard based on its recommendation by the end of 1995. The process of formalising the standard is still uncertain because of the potential for the FCC to face legal challenges from broadcasters or others if it takes any formal action to implement the standard.

Field testing of the systems so far has demonstrated that the proposed digital systems deliver superior picture quality and more reliable reception than NTSC.

The proposal encompasses MPEG-2 video compression and an overall data structure similar to that of MPEG-2, but has taken up Dolby AC-3 audio coding in preference to the MPEG proposed system (based on Musicam surround-sound). The proposed modulation system is 8-VSB, a single-carrier system that would rely on the use of an adaptive equaliser in the terrestrial transmission case. A related 16-VSB system is proposed for cable distribution. There has been some consideration of the use of COFDM modulation, but the prevailing view is that it could not be implemented in cost-effective consumer receivers. At this stage the US view on COFDM is that it is a fallback option if there are problems with 8-VSB. Final decisions on the transmission system will be taken following further comparative testing of the alternative systems.

Europe

The European DVB project comprises a core system which is intended to provide a general technical solution for all media. It is based on the use of the MPEG-2 video and audio coding system and the MPEG-2 transport multiplex. Common service information and scrambling systems will be available for all systems but the modulation and channel coding systems will be chosen to meet the different transport system requirements.

The DVB standards family has four members:

DVB-S The satellite system for use in the 11/12 GHz band, which can be configured to suit a wide range of transponder bandwidth and powers.

DVB-C The cable network system, compatible with DVB-S, and normally to be used with 8 MHz cable channels.

DVB-CS For use with television distribution systems in buildings- expected to be much the same as DVB-C.

DVB-T Designed for terrestrial channels with a nominal 7-8 MHz bandwidth.

The DVB-S and DVB-C specifications were the subject of the European Telecommunications Standards Institute (ETSI) public inquiry and were finally adopted as European standards in late 1994.

A digital terrestrial television broadcasting system reference model is being prepared, which will describe the options available for standardisation. This is expected to be completed during 1995. The current proposal for digital terrestrial television is based on the use of OFDM modulation. While there have been some suggestions that a VSB type system could allow early implementation and greater commonality with cable systems, OFDM remains the most likely system to be chosen.

Australian Technical Studies

Any new DTTB system in Australia will need to co-exist with existing PAL services until such time as the latter can be phased out. The DTTB Specialist Group has conducted detailed studies into the way in which DTTB might be accommodated within the existing terrestrial television broadcasting spectrum together with the existing PAL services. The channels identified for use by DTTB services are adjacent to those currently used by PAL services. They cannot be used for more PAL services because existing television receivers are unable to receive adjacent channels because of the signal 'spills' into the adjacent channel each side. DTTB receivers and the system as a whole will need to be designed to operate under these conditions by being able to ignore the 'spill' from the PAL channel and by avoiding the creation of interference from the new DTTB signals to the PAL service. Studies on all proponent systems will be necessary to measure whether interference will occur to the PAL service with an adjacent DTTB service, and what the planning criteria must be for such an arrangement.

Initial developments in digital terrestrial systems were based on 6 MHz channels (USA) or 8 MHz channels (Europe). With our 7 MHz channelling plan at VHF and UHF the DTTB Group was thus faced with the issue of how best to fit the proposed systems into the existing channel plan.

Consumer and Public Interest Issues

The Consumer Perspective

DTTB has the potential to provide a superior terrestrial television service for the consumer - not only through technical improvements but also in the provision of an increased variety of services and greater diversity of programming.

In assessing the best way to introduce DTTB, the involvement of existing broadcasters and its likely acceptance by consumers, a number of factors must be taken into account. These include the type of service, the range of programming which will be provided, how the consumers will be encouraged to move to DTTB, and the rate of consumer take-up.

These aspects will need to be considered in the wider context of technical and industry perspectives, recognising, that consumer acceptance of DTTB will be critical to its success.

To this end, future policy development and changes to the legislation will need to be considered in the wider public interest of a healthy industry and the provision of a wide range of quality services to the public.

Consumer Advantages/ Disadvantages of DTTB

One of the major questions is whether DTTB can provide consumers with a better broadcasting system which, in the spirit of the *Broadcasting Services Act* 1992, can contribute to the diversity and quality of broadcasting services available.

Natural Advantages of Terrestrial Transmission

The main advantages of terrestrial television over other types of program delivery is its ability to provide a valuable mix of national, regional and local programming without the need for expensive infrastructure (cable).

Terrestrially transmitted services can be networked to provide national coverage yet retain the capacity to provide regional and local services to the consumer (such as local and regional news, sport, current affairs and advertising) within 'windows' of the national program. Satellite delivery cannot provide this localism yet, and it will be many years before cable reaches rural areas. DTTB opens the possibility of true 'portable' television reception which may work equally well for powerful satellites but can never be achieved for cable sevices.

Improved Picture Quality and Reception

DTTB can provide higher quality pictures and sound (with new larger, wider screens), and better reception (with fewer problems related to ghosting, noise and interference). These technical improvements to the signal quality and its reception provide obvious benefits to the consumer.

Some may question whether these are important or significant improvements to what consumers are seeking from broadcasting services. For example some argue that the public has shown a greater interest in audio quality than picture quality, and that it has expressed only relatively minor concern about transmission impairments. As consumers become acccustomed to higher picture quality (for example, through satellite or cable services), they are likely to expect a similar performance from terrestrial television services.

Integration of Television with Telecommunications and Computing

The adoption of digital transmission technology will enable terrestrial television to take advantage of the developments in telecommunications and computing. This could make it far easier for the consumer to access future multimedia services.

More Efficient Use of the Spectrum - Increased Number of Program Channels and Services

The eventual exclusive use of digital technology should lead to much more efficient use of the broadcasting spectrum. This goal will not be fully achieved until analog transmissions have been phased out, perhaps twenty years from now. However,

the possibility exists for either a greater number of channels or further enhancements to the picture in the future (e.g. three dimensional images, home cinema, additional services, enhanced data services and specialist services such as those directed at the hearing or visually impaired).

DISADVANTAGES OF DTTB

Viewer 'Overload' in Relation to New Services

In the next five to ten years, a wide variety of new services will become available to Australian viewers, such as pay TV provided via satellite, cable or microwave, and open narrowcasting services like home shopping, interactive television and ethnic language programs.

How will consumers respond to the wide array of services available? There might be simply too many services coming onto the market at the same time to allow consumers to make fully informed decisions about their participation. Some could find any anticipated change to one of the few remaining familiar types of broadcasting service available - free-to-air television - potentially threatening.

Accordingly, the introduction of DTTB should take into account possible consumer hostility towards 'being forced' to adopt DTTB, and consider strategies which might help to alleviate this need to be considered.

Accommodating DTTB

Spectrum Availabiltiy

All current proposals for DTTB plan to use the channels between the analog services currently using the broadcasting bands. Those channels cannot be used for further analog services because of technical constraints inherent in those systems. These 'unusable' channels are generally called 'taboo' channels.

The ATSC in the USA determined that use of the taboo channels in the USA would allow each broadcaster to have an additional channel. The FCC intends to allow each broadcaster first preference for an additional DTTB only channel. The DTTB channel so allocated will be required to simulcast programming using the 'HDTV' digital standard adopted for USA.

In continental Europe the availability of channels for DTTB is much lower. Countries like Italy have virtually none, while others range from 20% to 70% of the desirable capacity. In Europe the television spectrum has been exploited intensively on an interference limited approach involving extensive networks of translators. For much of Europe planning for DTTB will be very difficult and intro-

duction of DTTB might only be possible on an incremental basis.

The UK has determined that it could provide simulcasting to at least 70% of the population, subject to the previously proposed analog fifth network not proceeding.

In Japan there is insufficient terrestrial spectrum for early introduction of DTTB.

Australia appears reasonably well placed to take advantage of this new technology, although past decisions will influence the choice of the most suitable system. The basic structure of terrestrial planning has more similarity to the separate service area pattern of planning used in USA than the nation-wide national broadcaster focused planning of continental Europe.

Planning in Australia has been influenced by the major distribution of population along the eastern seaboard and relatively low density settlement elsewhere. As a consequence coverage in many parts of Australia is limited by noise rather than interference. The 'taboo' channels will generally be able to provide about six DTTB channels in all markets while existing PAL services remain. Bands I and II (VHF) are not expected to be suitable for the DTTB transmissions. Bands III (VHF), IV and V (UHF) are suitable. The Australian television broadcasting spectrum has been planned using channel widths of 7 MHz, in both VHF and UHF. As discussed earlier this may mean that 8 MHz channel systems being developed in Europe might be difficult to accommodate. However, 7 MHz variants are expected to be available to meet the 7 MHz channels used in VHF in Europe. The US system is 6 MHz wide which can be easily accommodated.

Finding Spectrum for DTTB

To introduce a DTTB service into Australia within the short to medium term suitable channel allocations which will protect the existing PAL services must be identified.

Available Spectrum

The channels currently used for television in Australia are set out below.

Band I is not considered suitable for DTTB. Band II is unavailable for any new services because this spectrum is

Band	I	Channels 0, 1, 2
Band	II	Channels 3, 4, 5. Channel 5A also included here for convenience- new services are not being assigned these channels because the frequencies used by channels 3,4,and 5 are needed for FM radio and channel 5A is to revert to non-broadcast use
Band	III	Channels 6 to 12
Band	IV	Channels 28 to 38
Band	V	Channels 39 to 69

needed for FM radio broadcasting. DTTB allocations will therefore need to be confined to Bands III, IV and V.

Some of the spectrum in these bands is not currently available to broadcasters. In Band III channels 9A and 12 are currently used for aviation distance measuring equipment. In addition, channel 9A is only 6 MHz wide and cannot be used in the presence of existing channel 9 and 10 stations without moving the frequency of the channel 10 service and perhaps some channel 11 services might also need to move.

Channels 36, 37 and 38 at the top of Band IV have previously been shared with radio navigation and have been allocated to television services in only a few places. These channels have recently been returned to the ABA for broadcasting use and are available for DTTB planning.

Channel Width

With the exception of channel 9A[3], all Australian channels are 7 MHz wide. Unless a suitable 7 MHz[4] bandwidth system is developed and adopted for Australia, planners need to consider the options of:

- using a 6 MHz DTTB in a 7 MHz channel.
- using an 8 MHz DTTB in a 7 MHz channel and 'borrowing' 1 MHz from the adjacent channel. This implies the adjacent channel is available and can be reduced to 6 MHz.
- modifying the 8 MHz DTTB to 7 MHz and putting it in a 7 MHz channel.

The accommodation of a 6 MHz signal is, in a sense, a trivial issue. Clearly a 6 MHz signal could be easily accommodated, and might facilitate the transitional period (the extra 1 MHz perhaps helping minimise mutual interference between digital and PAL). There is, however, a longer term issue of spectrum efficiency which would lead to a need to adjust the assignments to remove unused (frequency) space. Indications are that this could be a difficult process as a number of respondents to the discussion paper have indicated substantial problems in changing the transmit frequency.

Accommodation of an 8 MHz signal is more problematic. At UHF, the existing channel plan provides 14 MHz gaps between channels in use in any given location so an 8 MHz signal could perhaps be dropped into the gap, but that would reduce the available capacity (two 7 MHz signals could use the same space) and might not provide sufficient channels to provide digital outlets for all existing services to move to DTTB. Australian studies to date have looked at the 'worst case' of accommodating COFDM signals with a nominal 8 MHz bandwidth into the Australian 7 MHz channel plan.

Our studies have looked at the possibilities for retaining a full 8 MHz

3 Channel 9A is intended to be 7MHz wide but to achieve this Channel 10 must move 1 MHz.

4 Present US developments are for a 6 MHz bandwidth system, while those in Europe are for 8 MHz bandwidth.

channel width signal, but overlapping that signal with the edges of a PAL signal. Rechannelling the spectrum into 6 or 8 MHz channels would result in:

- Band III (174 to 230 Mhz) — 9 x 6 MHz channels or 7 x 8 MHz channels.
- Bands IV and V(520 to 820 Mhz) — 50 x 6 MHz channels or 37 x 8 MHz channels.

However, neither scheme is considered practical because of the very significant disruption that would occur to the services using the existing broadcasting plan, so the spectrum studies to date have assumed a nominal 7 MHz channel.

Planning Assumptions

At this stage there are no government decisions about whether or when to introduce a DTTB service, nor about how many channels should be provided, nor about automatic participation of existing broadcasters. For the purposes of initial planning studies, the assumed goal has been to attempt to identify sufficient DTTB capacity to replicate the existing PAL arrangement of six channels nationwide while still retaining the present PAL assignments. In some regions (e.g. Central Coast NSW, Gold Coast) there could be a need to provide at least eight DTTB channels.

The planning criteria adopted assume that DTTB services should operate in the same bands and with the same polarisation as existing PAL services in order to minimise viewer inconvenience and avoid a possible impact on the takeup rate for DTTB. Similarly, DTTB transmitters should be co-sited with existing PAL transmitters. This would simplify antenna pointing and limit the differences in received field strength between PAL and DTTB services to those necessary to allow DTTB to operate in parallel with PAL.

DTTB receivers should tolerate higher levels of co-channel and adjacent channel interference than current PAL receivers, but at the same time, planners must accommodate the performance limitations of the large base of installed PAL receivers. Better adjacent channel performance in the DTTB receiver will be important to DTTB spectrum planning. Unless DTTB can use channels adjacent to existing PAL services in the same coverage area, it may be impossible to find enough channels for DTTB services and parallel PAL services, and/or to keep services within the same band as existing PAL services.

In order to protect the existing PAL services from interference from adja-

Polarization: television signals are either horizontally or vertically polarized. In simple terms if the bars on a televison antenna must be horizontal to receive this service it is horizontally polarized. If they must be vertical then it is vertically polarized. A receiving antenna can discriminate between horizontal and vertical signals and this is used by planners to allow transmitters to be more closely spaced.

cent channel DTTB services, an important constraint in the introductory phase will be the maximum tolerable difference in the power of the adjacent channel PAL and DTTB service. This is illustrated in Figure 3. These conditions imply that, if adjacent channels are used, DTTB services must be operated at least 9 dB below adjacent PAL services[5] but must be no more than 37 dB below the PAL service so as to prevent PAL services causing interference to the DTTB service.

These figures are based on preliminary receiver design performance criteria from Europe and the USA. We do not know yet how realistic these figures are. They set a window on the possible range of DTTB transmitted power levels relative to co-sited PAL services.

An important planning issue will be the field strength levels that define the edge of coverage area of the DTTB service. Selection of an appropriate value requires assumptions to be made about:

- receiving system performance (receiver noise figure, antenna gain, cable loss etc.).
- channel data rate (this determines whether standard, enhanced or high definition can be provided; alternatively it determines the number of standard definition channels that can be accommodated in the channel).
- percentage of locations within the nominal coverage area that receive a signal strength above the required minimum planning field strength.
- percentage of time for which these locations receive at least the minimum specified field strength.

Planning is made more complex by the potential consumer reaction to the way in which digital signals fail under weak signal conditions. For analog services weak signals are heralded by visible electrical noise on the screen (usually white flecks or 'snow'). Digital signals can be

[5] In sub-committee deliberations an upper adjacent channel protection ratio of 3 dB was discussed but this was found to be based on European 8 MHz channelling which effectively puts a 1 MHz guard band on the upper edge of each PAL channel. Initial measurements of Australian receivers indicate that protection ratio of approximately 10 dB for both upper and lower adjacent channels is more appropriate for a 7 MHz channelling condition.

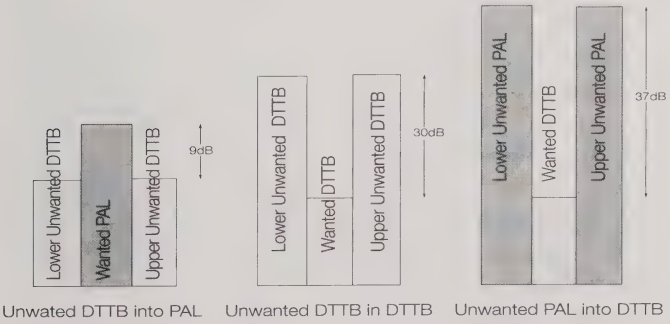


Figure 3: Maximum tolerable difference in power of adjacent channel PAL and DTTB service.

extracted noise free at much lower levels of signal strength down to a certain point where the signal can no longer be extracted and there is no longer any picture to display or the last complete form remains frozen on the screen. Thus the signal (as far as the viewer is concerned) seems to stop for no or little obvious reason.

Current Australian PAL VHF planning provides an edge of coverage area field strength of 62 dBμV/m (band IV) which will provide at least 50% of locations with a service at least 50% of the time (usually designated E 50:50). This is a statistically devised planning parameter which ensures the majority of people in the coverage area can obtain satisfactory service with normal antenna installations, without the necessity for planners to attempt to make separate computations for each location. It also takes into account the normal random fluctuations in the signal level covered by propogation factors. The sudden failure behaviour of DTTB at the limit of coverage is expected to be inconsistent with a new high quality service. It is considered necessary to plan the DTTB on the basis of providing a required field strength over 90% of locations at least 50% of the time (ie. E 90:50).

This more demanding service requirement implies a field strength for DTTB that may need to be up to 12 dB higher than would have been needed for an E 50:50 planning model. This field strength increase can only be achieved through higher transmitter power and/or antenna gain, so it cannot be taken lightly. The saving grace is that digital systems planning can start from significantly lower power levels than analog systems.

From the research so far conducted by the Specialist Group Spectrum working party, three different service quality targets have been identified that could be used as the basis for further DTTB planning studies. For UHF Band IV these are:

- standard definition coverage encompassed by a contour which provides 90% of locations with a field strength level of greater than 37 dBμV/m (alternatively this contour could be considered as providing greater than 49 dBμV/m to 50% of locations within the contour).
- enhanced definition coverage encompassed by a contour which provides 90% of locations with a field strength level of greater than 43 dBμV/m (alternatively this contour could be considered as providing greater than 55 dBμV/m to 50% of locations within the contour). (As an alternative to providing a single enhanced definition service it may be technically possible to provide two standard definition DTTB services using the same channel bit rate capacity).
- high definition coverage encompassed by a contour which provides

90% of locations with a field strength level of greater than 49 dBμV/m (alternatively this contour could be considered as providing greater than 61 dBμV/m to 50% of locations within the contour). (As an alternative to providing a single high definition service it may be technically possible to provide four standard definition DTTB services using the same channel bit rate capacity.)

By comparison, current E 50:50 PAL planning for Band IV requires that a field strength level of 62 dBμV/m be provided.

Accordingly, if a DTTB service is to provide a high definition service to 90% of locations within its nominal coverage area it will need to operate at a similar ERP as current PAL services which are planned on an E 50:50 basis.

In the interim phase when PAL and DTTB services have to co-exist, reduced transmitter ERPs can be achieved if the DTTB service were planned to provide enhanced or standard definition rather than high definition services. This may not assist the early adoption of the new services. Another approach would be to provide a high definition service but to accept that in the interim phase, a lesser standard of coverage may need to be accepted at the fringes of the coverage area. (The practical implication of this might be a need for use of higher gain receiving antennas or lower noise figure receivers towards the edges of the coverage area). Note that multi-program transmissions may require the same signal strength at the limits of coverage as that needed for high definition service.

Transmission Facilities

Many of Australia's transmitting sites were recently re-engineered to facilitate the additional requirements of the Federal Government's Equalisation of Regional Commercial Television program. This work was done at great cost and is unlikely to be economically feasible to duplicate fully for DTTB, particularly in areas of modest population.

The problem of introducing DTTB to these sites includes the need for regional broadcasters to have time to amortize their massive investment in antenna systems, channel combiners and other indoor plant. Many transmission towers are now fully loaded and cannot accommodate further large broadcast antennas. Those towers typically support a Band II FM antenna, a channel specific Band III antenna as well as a Band IV or V array. Environmental considerations make it very difficult to consider new sites or even additional towers at existing sites.

The use of adjacent or near adjacent channels for DTTB on the same polarisation as the PAL makes it possible to consider deploying some of the existing plant to the new service

as well as meeting the needs of the viewers as discussed previously.

The DTTB group has considered whether some of the existing PAL channels might be changed to facilitate the provision of DTTB capacity. This would be difficult in practice because of:

- the costs involved.
- the impact on viewers.
- the impact on commercial balance in markets if some broadcasters at a given location must change frequency while others do not.

Coverage Area

Even a small change in frequency (e.g. 1 MHz) can be sufficient for some receivers to lose the signal. While this can be easily corrected by retuning the receiver, in practice consumers find retuning modern receivers quite difficult. Retuning is usually never needed after installation so they have no familiarity with the procedure and may need to call a technician.

The process of planning channel allocations needs to take account of the social and commercial arrangements under which the existing PAL services have developed. Broadcasters and consumers are likely to expect DTTB to retain their ability to:

- have separate time zones.
- recognise state borders
- separately identify and segment larger licence areas into components such as:
  - approved markets
  - sub market eg. Canberra
  - local area e.g. Goulburn or Parramatta.

Network Structures

Australian analog spectrum planning has been established using ITU recommended practices. It can be considered as being based on a grid where each main station coverage area is surrounded by three neighbouring areas. To avoid co-channel interference in adjacent areas, neighbouring areas use different frequencies. This means that nationwide coverage requires, at least, three channels per service provided. (i.e. 18 free channels for six services).

When allowance for gap filler and coverage extenders is included the number of channels per service provided will be even higher. When considering the planning basis for DTTB there are two major options:

- effective replication of current PAL planning.
- using features of the DTTB signal format to operate networks of transmitters on a single frequency. In single frequency networks (SFNs) receiver signal processing is used to avoid co-channel interference in overlap regions between transmitters. The SFN concept has so far only been actively promoted for

COFDM based DTTB systems. Further study is needed to see if it can also be applied to single carrier digital systems[6].

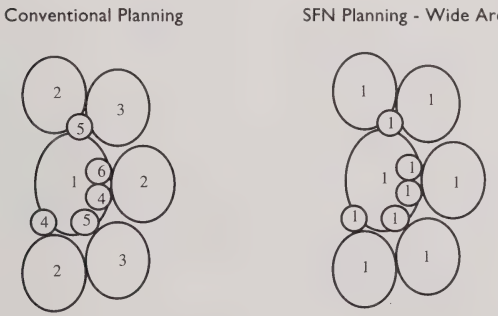
If conventional PAL planning is applied to DTTB spectrum planning there might not be enough channels to provide a full six channels DTTB service throughout the nation including provision for translators. It might restrict the introduction of a DTTB service to main stations (and high powered translators) initially until PAL services are cleared. In all probability modified planning methods may be possible with DTTB, although the underlying principles will remain the same.

SFNs can be implemented at national, state, aggregated market, sub-market or local levels. The greatest efficiency in spectrum use is achieved with the larger sized SFNs, however there are still advantages even for as few as two transmitters in an SFN. Given the likely difficulty in finding enough channels to provide a full national DTTB service, SFNs are a powerful concept which should not be lightly abandoned.

There are however some objections to very large area SFNs. In particular, commercial operators are concerned that spectrum plans based on SFNs may lock them into coverage areas which preclude segmentation of the market through the provision of smaller locally based services. Another concern is how SFN transmitters will be fed. Conventional off-

6 ITU-R document (TG11-3/111) indicates that if the ratio of wanted to unwanted co-channel signals can be maintained above the ratio needed for satisfactory adaptive equaliser operation then SFNs using single carrier modulation systems can be designed.

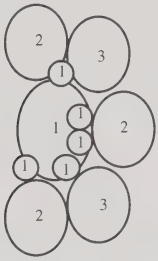
Figure 4: Different Network structure approaches



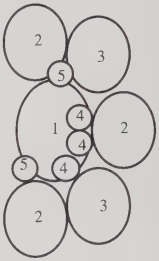
Channels 1, 2 & 3 are main service areas with fill in translators 4, 5, 6

Figure 4 (cont.) : Different Network structure approaches

SFN Planning - Submarket area based



Quasi 'SFN' Planning



air feeding presents difficulties in avoiding self-oscillation of the translator. To avoid this, feeding needs to be achieved by a separate method e.g. microwave link. This might mean that feeding of SFNs may be more expensive than for existing PAL translators.

A possible compromise is a quasi-'SFN' approach. In this case a main transmitter would operate on one frequency but low power translators operating from it would operate as SFNs on one (or two) other frequencies. This would give broadcasters a degree of flexibility to reconfigure to a more localised operation in future and be an effective way of providing 'in-fill' coverage to places which can't be served at present. The full implication for spectrum efficiency, public interest, commercial needs have yet to be fully explored.

Conclusion

The introduction of DTTB will require planners to select channels that create the least disruption to the existing PAL services. In any geographic area, this will involve the use of currently unassigned channels that are invariably adjacent to a PAL transmission and possibly co-channelling another service.

The studies to date show that without the wholesale (unacceptable) relocation of most existing stations the task will be difficult but not impossible. Any further allocations of either PAL or non broadcast services in Bands III, IV or V will make the task even harder.

The final solution will depend on the modulation scheme chosen for Australia as well as the occupied bandwidth of the channel.

Some Preliminary Views on Objectives for DTTB in Australia

Results of Public Consultation and Studies by the ABA DTTB Specialist Group

The DTTB Specialist Group has proceeded with technical studies and a parallel canvassing of public comment through the publication of the ABA discussion paper *'Digital Terrestrial Television Broadcasting in Australia - Issues and Options'*.

The contributions received in response to the Discussion Paper, and the continuing studies of the Specialist Group have led to the development of some preliminary views about the way in which DTTB might be introduced in Australia.

While answers to some of the questions raised in the discussion paper are not yet evident, the public contributions and further studies have helped to refine the options and identify the principal objectives. For convenience these preliminary views are set out under headings reflecting the main issues outlined in the discussion paper.

HDTV or Multi-program

In the original discussion paper this issue was stated 'HDTV and/or multi-channel'. This seems to have confused some readers so the Specialist Group has now adopted the term multi-program services as one which more accurately describes one of the features DTTB could provide.

At the present stage of DTTB development it is possible to accommodate about 24 Mbit/s and 30 Mbit/s data streams, respectively, into 6 MHz (US) and 8 MHz (Europe) wide terrestrial television channels. This data can be used to transmit either one HDTV or, 4 to 5 lower definition (which the Europeans refer to as standard definition television) programs. In addition to this capability, DTTB will have capacity to carry ancillary data services. There will be some capacity to carry these in parallel with HDTV or multi-program services, or to carry additional data at the expense of one or more low-resolution multi-programs. This could further enhance the flexibility of DTTB in Australia. With the present PAL system only one program can be transmitted per 7 MHz television channel.

The discussion paper described the single HDTV approach as being aligned to the US approach to DTTB planning and the multi-program as aligned to the European approach. Since then, US television broadcasters are increasingly advocating a multi-program form of Advanced Television. Some have argued that multi-program capability will help to defray the costs of moving to DTTB and make them more competitive with cable. Others see wide-screen HDTV as a better selling point, and express concern that unless broadcasters make use of the HDTV capability, they might put at risk their guarantee of entry to this new technology.

The discussion paper asked whether Australian DTTB should provide for a single HDTV program or have the flexibility for the broadcaster to switch between the single HDTV mode and multiple program modes. This would provide several separate programs at lower quality grades depending on the type of material being transmitted (e.g. HDTV for fast action sport and 'blockbuster' movies, multi-program for news, standard movies, etc.)

The public responses to this key issue showed a clear desire for Australia's DTTB to be flexible enough to provide for either a single HDTV quality television program (or perhaps more), or a greater number of standard quality television programs depending on the program material. A flexible DTTB system offers benefits to television broadcasters and audience alike. The broadcaster is able to maintain a competitive service in an increasingly diverse video entertainment environment including MDS,

cable and satellite subscription television and other video services. The audience receives a wider range of free-to-air television services in a quality appropriate to the program content.

At present, there appears to be a wide range of opinions about whether the public is satisfied with the current range of broadcasting services and to what extent they are prepared to pay for any new services which might become available.

The first likely indication of consumer preference for a particular system may centre on whether there is a perception that new pay TV services are able to provide sufficient additional choice and diversity in programming, or whether consumers, particularly those who do not have access to these new services for various reasons (geographical location or level of disposable income), also desire greater programming choice from free-to-air television.

Additional free to air programs do not come free. In addition to the infrastructure investment, broadcasters must acquire the programming, and face the prospect of greater fragmentation of the audience. There is no certainty that multi-program delivery will produce any significant returns to the broadcaster who must rely upon advertising revenue to survive. Perhaps a very flexible mix is necessary to enable broadcasters to explore potential new business opportunities, and new content as ways to attract new audiences rather than see DTTB as a simple high quality or multi-outlet replacement for traditional television delivery.

Preliminary View 1

The substantial weight of opinion expressed in the public comments and within the Specialist Group, is that DTTB services introduced to Australia will need to have the flexibility to meet market demand. Premature restriction to specific technical quality or service targets may stifle the market driven development of the service. Broadcasters will need to experiment and react to their audience in a dynamic way to encourage the purchase of new receivers.

The ABA considers these arguments have merit but further information about technical developments, and market exploitation is needed before any firm position can be developed on how multi-program versus HDTV issues should be addressed.

Termination of PAL Services

Responses from television broadcasters generally support a full transition to DTTB over time. Manufacturers, broadcasters and other interested parties clearly support the retention of PAL services for a minimum period of 15 years with the actual termination date being determined by the market place.

A major factor which will influence the decision to terminate existing PAL services is the significant infra-

structure and investment by broadcasters and viewers throughout Australia to support and receive existing PAL television services.

Currently the number of PAL television receivers and VCRs in the market place throughout Australia is about nine million and four million respectively. Typically television receivers have a useful life of between 10 and 15 years.

Irrespective of when DTTB services commence in Australia, a significant number of PAL television receivers and VCRs will remain in operation, thus requiring the retention of PAL services for an estimated ten to twenty years from the commencement of DTTB services. Therefore, a policy allowing for the transmission of both PAL and DTTB services for a period of time seems desirable. The final termination of PAL services will ultimately be determined by the acceptance of DTTB services by the consumer and broadcasters.

Public acceptance of DTTB will be largely governed by the perceived benefit this new technology will provide. Both broadcasters and receiver manufacturers must provide realistic incentives to encourage the public to convert to new DTTB services.

A critical public interest issue is how to ensure that the transition from analog to digital transmission is effected in a manner which is easily understood and relatively uncomplicated, fair, cost effective and able to be undertaken in a reasonable time frame.

In the USA and Canada most or all current NTSC licensees will be allocated another channel to begin digital transmission. Once the transition stage is over, the NTSC channel will be reclaimed. At present DTTB in the USA is seen as a 'replacement technology', rather than another form of television delivery which should be opened up in the transition period to new players. In the United Kingdom, for example, existing terrestrial broadcasters will have the opportunity of being allocated a digital channel, with additional channels being available for new services.

In most countries where DTTB is under consideration, there appears to be agreement that a realistic transition to DTTB requires the full participation of existing broadcasters. DTTB implementation strategies in those countries aim to provide existing broadcasters with an opportunity to move to DTTB, have time to develop new formats, and if necessary, new programming. This strategy should allow a more orderly introduction of new services and be more likely to promote total transition to DTTB, with the least possible impact on the viewing public.

A strategy of total migration of services to DTTB opens the way for releasing spectrum currently used by PAL services. A transitional strategy

does not require Government to make decisions immediately about how this spectrum might eventually be used.

Preliminary studies discussed earlier show that within the present spectrum allocated to PAL television broadcasting in Australia, at least one digital channel could be made available for each existing television transmitter without affecting the continuation of existing PAL services. This suggests development of DTTB via initial migration of existing broadcasting services is feasible.

Preliminary View 2

The termination of existing PAL services assumes existing services must at some point migrate to DTTB. An arrangement to allow existing broadcasters to be allocated an appropriate DTTB channel and be able to operate this channel in parallel with their existing channels would facilitate the introduction of DTTB.

The termination of existing PAL transmissions will depend largely on when DTTB services are introduced in Australia, the level of acceptance of DTTB services by the consumer and the penetration of new DTTB television receivers. Other factors such as cost to the broadcaster and consumer, quality, quantity and variety of entertainment services will be significant.

No actual time period or date can be fixed at this point in time for the termination of existing PAL services in Australia. After a decision is taken to launch DTTB in Australia, the termination date for PAL should be subject to regular review and the decision made in a consultative process by both industry and government organisations.

Use of VHF or UHF Bands

There appears to be no technical constraint to the use of VHF (Band III), UHF or both television bands, for the introduction of DTTB in Australia. Responses to the ABA support this view and that of the specialist group that VHF television Band I (channels 0,1 & 2), or Band II (channels 2, 4 & 5 in the FM radio band), are unlikely to be suitable for DTTB.

Receiver manufacturers tend to favour the use of the UHF bands alone for DTTB, while broadcasters see distinct advantages in using VHF Band III as well as the UHF bands, at least for the development of DTTB. There is not enough spectrum available in VHF Band III alone to accommodate existing broadcasters on DTTB as well as the existing PAL services. Some broadcasters have suggested DTTB be introduced on VHF in capital cities and on UHF in regional centres. Others have indicated that this policy should be conditional on a VHF channel being available for all incumbent television broadcasters, so that all DTTB services are on the same band in any given market.

Some respondents, in the manufacturing industry and in research, suggest movement of television from VHF to UHF to allow the VHF bands

to be reallocated for mobile communications. These people suggest interim development of DTTB in VHF Band III, then migration to UHF once PAL services in the UHF band cease. Others in research suggest that DTTB should be 'UHF only' from its inception, to allow economies of scale in receiver manufacture for a 'world wide' market.

An all UHF option for DTTB would be possible in the long-term but the problem of migration would impact on large numbers of people if services were to commence on VHF then change later to UHF. Irrespective of what option is selected, in the end all digital terrestrial television services in an area should be in the same band, either VHF Band III or UHF.

The Federation of Australian Commercial Television Stations (FACTS), representing commercial television broadcasters, suggests that all licensees should be offered an additional channel, either VHF Band III or UHF, for the development of an advanced television service. FACTS suggested that all main metropolitan VHF television service licensees should be allocated a VHF channel for DTTB development, and that in regional areas a UHF channel may be more appropriate. The ABC (which uses a Band I channel in the capital cities (channel 2)) would also expect a VHF Band III channel for their DTTB services. The SBS already has a UHF only network, and would like to see all existing television services develop DTTB on the UHF bands because there would not be enough for all broadcasters to establish a DTTB service in the available VHF spectrum. If other capital city broadcasters are allocated VHF channels, the SBS has asked that it too be allocated a VHF channel.

All broadcasters prefer an adjacent channel for DTTB. The ABC would like channel 12 to replace channel 2, and then be allocated channel 11 for DTTB development. The SBS would not wish an adjacent UHF channel if all other broadcasters are on VHF. Under this scenario ABC and SBS would need to be allocated channel 11 and 12 for DTTB. The introduction of VHF Band III channel 9A, when it becomes available for broadcasting use, may cause some difficulties if existing channel 10 and 11 PAL services have to move upwards by 1 MHz to allow for realignment of these channels to fit the new channel 9A between channels 9 and 10. Otherwise channel 9A would be only 6 MHz wide, rather than the standard 7 MHz bandwidth.

The ABC suggests that an all UHF DTTB implementation would also be acceptable if Band III were retained solely for existing PAL services and all five television broadcasters were on UHF for DTTB in capital cities.

Most television viewers have suitable receiving antennas for VHF Band III

and some UHF television services. Most viewers in Australia already have VHF Band III receiving antennas. Many capital city viewers also have Band IV antennas. Increasingly, people in the capital cities watch television services through UHF Band IV and V translators, and many viewers in regional areas receive their primary television services on the UHF television bands.

In capital cities existing VHF Band III receiving antennas (some of which are more than 35 years old) may not provide adequate DTTB reception (particularly for reception of channels 11 and 12). On the other hand, any new services on UHF Bands IV and V will require many viewers who currently do not watch UHF services to install new UHF antennas.

A further major consideration is the provision of transmitting facilities. It may be relatively easy to couple a DTTB service to an existing VHF or UHF antenna system, but it may prove very difficult and expensive to accommodate new antennas for another band on the existing masts.

Preliminary View 3

Irrespective of what band is to ultimately be used for DTTB, DTTB should desirably commence in the band where it will permanently reside. This will ease the burden on consumers.

Further studies need to be undertaken to determine whether it would be possible to accommodate all potential services on UHF and for all DTTB services to commence on UHF while there is an incentive of adopting the new technology.

A mix of VHF Band III and UHF may be required to accommodate the demands for DTTB. Initial studies suggest DTTB could use VHF Band III in the capital cities but UHF will be required for DTTB in regional and country areas because of scarcity of VHF Band III channels.

Further studies need to be undertaken into the feasibility and cost of UHF options for DTTB both from the broadcaster and consumer perspective so that any decision on the appropriate band for DTTB will be fully informed of the costs and benefits.

Channel Spacing (Bandwidth)

At the time the discussion paper was released, development of the European standard for DTTB focused on the use of a channel bandwidth of 7 or 8 MHz, while the USA planned for 6 MHz bandwidth. Neither group was developing a system to suit the existing Australian 7 MHz channelling plan, used in the VHF and UHF bands. Since then there has been more interest in Europe in developing a 7 MHz variant of the COFDM system to cater for the 7 MHz channelling plans used in Europe at VHF (European UHF usage is standardised on 8 MHz channels regardless of the television standards used) and in other non-European PAL television countries.

As mentioned earlier, technical studies have been conducted into various aspects of this problem. These suggest that the accommodation of a 6 MHz system is trivial but there remains a question of what to do with the remaining 'vacant' 1 MHz from the 7 MHz channel. Accommodation of the 8 MHz system is more complex.

One simple solution is to just curtail the ensemble of OFDM carriers so as to occupy a 7 MHz channel. Disadvantages of this include reduced data-rate compared to the 8 MHz case and the possibility of requiring special transmitting and receiving equipment for Australia. The practicality of this approach also needs to be verified. For these reasons, the studies of this approach have been held in reserve.

Three possible options appear to exist for putting an 8 MHz system into a 7 MHz structure: symmetrical overlap with the COFDM signal centrally in the channel, overlap of the upper part (occupied by colour and sound components) of the lower adjacent channel signal or overlap of the lower part (vestigial sideband) of the upper adjacent channel.

These studies are still in progress. It has been necessary to develop specific test equipment for the purpose in order to develop a family of protection ratio curves for different amounts of overlap of the (simulated) COFDM signal of a PAL signal.

Initial results were submitted to the October 1994 meetings of ITU-R Task Group 11/3 and work is now proceeding to build on these initial studies. The tests will be extended to consider both 6 MHz and 7 MHz band-width COFDM signals as well as the initial 8 MHz tests.

All studies so far have involved simulations using laboratory equipment. Confirmatory measurements with actual transmitting plant will be necessary when this becomes available because its performance may be critical to the spectrum assumptions made.

There is interest from Canada, and some interest from the USA, in the possible adoption of COFDM modulation for the North American ATV service. But this is somewhat 'on the back burner' pending completion of the field trials of the proposed 8-VSB modulation system. The development of these variants of COFDM would increase the options available to Australia for a digital television system.

Retention of the existing 7 MHz plan is widely favoured as a way of minimising costs and inconvenience for broadcasters and the public. Consistent themes in submissions on the discussion paper were the desire for minimum disruption to existing arrangements (including retention of a 7 MHz channel plan although at least one respondent suggested seizing the opportunity and reverting to an 8 MHz UHF plan).

One difference between the two possible systems is that, while US activity has centred on a wideband single carrier, Europe has been concentrating on multi-carrier COFDM systems. Multi-carrier systems are generally considered more adaptable to sharing with existing services, by making use of their relative immunity to narrow band interference.

6 MHz

The use of 6 MHz channel spacing in conformity with US standards was given some support in the submissions.

One argument was that the use of 6 MHz spacing would offer greater spectrum utilisation efficiency by allowing more channels to fit into a given bandwidth.

A broadcaster submitted that choosing a bandwidth wider than 6 MHz would require raising channels 10 and 11 by 1 MHz, and that the resulting need to retune all television receivers and video recorders in Australia would be a massive task, leading to inconvenience and placing some broadcasters at a severe competitive disadvantage.

No suggestions were received about what should be done with the 1 MHz of spectrum 'left over' if 6 MHz digital systems were used with 7 MHz channel spacing.

7 MHz

The use of 7 MHz channels for DTTB is also supported by a view from a major manufacturer that it is technically feasible to adapt the European system to suit 7 MHz channelling, with the result that systems with 6 or 8 MHz bandwidth need not be introduced into Australia.

Further support for the use of a 7 MHz compatible system comes from the broadcasting industry, which suggests that the introduction of DTTB would not justify a change in the spectrum plan and the associated costs for broadcasters and viewers.

8 MHz

An alternative proposal made in some submissions was that Australia could use 8 MHz channel spacing for all UHF channels and, if required for DTTB, also broaden the Band III channels to 8 MHz. The reduction in number of channels could, it is argued, be offset by taking advantage of improved spectrum productivity possible with digital systems as a result of lower protection ratios. There are also arguments that Australia, with its comparatively small population, should not depart from world standards.

Preliminary View 4

Considering the support for retention of 7 MHz channelling, using either the US system or a variation of the European system and the massive changes that would be necessary to existing television services to move to 8 MHz channel spacing the ABA considers priority should be given to addressing how the candidate systems might most efficiently be accommodated within the existing frequency allotment plan.

The ABA shares the concern that, if it became necessary to develop a 7 MHz system specially for Australia, it could result in unduly expensive receivers and Australian viewers and broadcasters could suffer because of its lack of standardisation with the systems in use in other parts of the world.

USA or European Standards?

Some respondents suggested that selection of the US ATV standard would be advantageous in terms of equipment availability, timeliness and program exchange. However the accelerating rate of development in Europe suggests the gap is narrowing and these 'advantages' might rapidly disappear, leaving the choice to be made on other factors.

There was some support in several responses to the discussion paper for delaying the choice of standard until the world scene becomes clearer. There was concern that an early choice to suit forthcoming special events such as the 2000 Olympics, may lead to the introduction of the North American system, which the commentators saw as not necessarily providing the technical options best suited to Australia.

A number of submissions advanced criteria for selecting a system for Australia:

- the eventual choice should take into account the availability of broadcasting equipment and receivers to suit the system, to ensure that HDTV is available for the 2000 Olympic Games;
- technical quality should be satisfactory;
- to enjoy the economies of scale offered by world television manufacturers, Australia's DTTB must be aligned with the digital systems of other world markets;
- for maximum flexibility, the European standards with the wider channel width may be preferable;
- compatibility is desirable with the USA and other countries;
- harmonisation of the standards for satellite, cable and terrestrial television is desirable, favouring the European system;
- customer requirements should be taken into consideration;
- the chosen system should allow backward and forward compatibility with existing PAL services and consumer equipment;
- transparency is desirable between studio and transmission standards;
- receivers should be able to receive simulcast PAL services or usable for other purposes requiring display of PAL;
- multi-channel television programming is not needed because there are many other possible means of program transmission.

There was little support in the submissions for enhancement of the existing PAL system by using PAL PLUS, as an alternative to digital systems. Further support for the use of

PAL enhancements was given in one submission. This noted that Australia's eventual choice of digital television should be applicable to all modes of distribution and should be aligned with other world models. It also noted that there are more technical similarities with European than US systems.

Preliminary View 5

It is premature to make a choice of either system at present, particularly as there are signs of increasing convergence between the European and North American systems.

Further studies are necessary to define the specific characteristics of a system suitable for the Australian broadcasting environment.

Relevance of Pay TV Standards to DTTB

The Broadcasting Services Act 1992 provided for the holders of subscription television licenses A and B to agree to a digital transmission standard to be declared by the Minister after consultation with OPTUS. The Minister announced in the Commonwealth Government Gazette of 11 May 1994 that the standard to be adopted will ultimately be based on the IEC/ISO Moving Picture Experts Group standard MPEG-2.

Pay TV is the only area where procedures for determining standards for broadcasting have been set down in legislation. These procedures do not apply to the establishment of DTTB standards.

MPEG-2 specifications are also expected to be used for the basic coding and multiplexing of video, audio and data signals for DTTB. However, as pointed out in the earlier discussion of European DVB standards, even for systems based on MPEG-2 there is significant scope for differences between delivery systems. The differences between the transport systems could probably be accommodated in the integrated receiver decoder or included in an integrated receiver but the more complex such devices are the more expensive they are likely to be. Modular design concepts may be used to enable such devices to be tailored to individual consumer requirements.

The Specialist Group considers that while it would be desirable for a DTTB system to be compatible with other methods of transmission it is not an overriding consideration. This is also the view taken in most of the submissions received on this issue.

For the present, new services such as pay TV, will need to provide inexpensive interfacing to existing PAL receivers, much as was the case for introduction of VCRs. DTTB will see the introduction of purpose built true digital receivers which will eliminate the need for the digital transmissions to first be converted to PAL for viewing.

Preliminary View 6

The choice of the DTTB standard need not be related to the standard adopted for satellite pay TV or other pay TV services that might be introduced in the near term. However there does appear to be longer term advantages for the consumer if all services converge to a common or compatible family of standards.

Delivery of Television Services into Discrete Licence Areas

Television broadcasting in Australia has been planned to provide viewers with access to six television services through networks of terrestrial transmitters, though, in many areas, the fifth network (SBS) and the sixth network may not be operating.

Some television operators provide programs across the nation, others provide local or regional services. Most commercial services make provision for local news, advertising and community announcements. The insertion of local programs is facilitated by arrangements between major metropolitan-based networks and their regional affiliates and is made possible by using a number of transmitters to broadcast the programs. Some of these simply relay the signals originating from main transmitters, others are able to break into the main signal to introduce locally originated program material. The transmitters serving a region use different frequencies in order to prevent interference to the reception of services from the other transmitters. This facilitates the introduction of local content.

The European COFDM transmission single frequencies networks approach has the potential for extremely efficient spectrum utilisation in that for national coverage only one radio frequency channel is needed for the transmission of one DTTB service. Single frequency networks can also be used to provide seamless coverage in smaller areas such as a metropolitan area which now requires translators on different channels.

While there may be benefits in using single frequency networks, the capacity for local programming to be inserted would be negligible. Similarly, the insertion of local advertising would not be possible. The ability to have both targeted and localised advertising has benefits for audiences and advertisers. The retention of areas that could be independently programmed within a licence area would help preserve a measure of localism, or at least regionalism, in both programming and advertising. It also enables services to be aligned with local time zones.

Submissions received on this issue were virtually unanimous that television services should be capable of providing local programming, including local advertising. It is generally considered that there are significant commercial advantages for the televi-

sion stations concerned and for local business in retaining discrete local or regional licence areas and planning service delivery accordingly. The ability to include local programming in a service was also considered to have social and cultural benefits.

There were several suggestions that DTTB could be made available on single frequency networks for statewide or time zone coverage with local news being provided on the PAL channels or by local low power stations.

The Specialist Group has identified advantages and disadvantages in the adoption of single frequency networks, including potential planning difficulties in integrating single frequency networks within the present infrastructure. The Group concluded that the commercial and social advantages of discrete licence areas outweighs the advantages of single frequency networks. Therefore, while there may be merit in single frequency networks on a limited scale for in-fill relay within the primary coverage of a main transmitter, future television broadcasting planning should preserve capacity for discrete local and regional level programming within networked services.

Preliminary View 7

Introduction of DTTB should not reduce the possibility for television broadcasters to tailor programs for local and regional audiences, and hence contribute to access and diversity. Single frequency network principles may have advantages in some aspects of planning, particularly for translators and for regional services, further consideration should be given to the application of such networks when DTTB developments are further advanced. The ABA notes that single frequency network arrangements have at this stage only been demonstrated with the use of the COFDM type of transmission system.

Other Issues

In addition to covering the key points raised in the discussion paper, a number of additional points were either raised in the submissions or identified in on-going studies by the Specialist Group.

Timing

Some contributions have suggested the 2000 Olympics as a target date, noting that television in Australia commenced the same year as the 1956 Olympics in Melbourne. It is suggested that the Olympics could provide a valuable incentive for early marketing of the DTTB advantages.

Others are more cautious, noting that there is considerable work necessary, including full assessment of the financial implications. Additionally, at this stage there is no DTTB system in operation anywhere in the world and doubt about any significant operations before 1998. To achieve a year 2000 commencement, equipment would probably need to be ordered in 1997 at the latest.

Preliminary View 8

It is premature to reach any conclusions at this time on when it may be feasible to commence DTTB, but there will be much better information on which judgements can be made within the next 12 months.

Convergence of Technology Opportunities

Multimedia and interactive video are gaining rapid acceptance by consumers and operate on PC platforms. They offer full motion interactive high quality video as well as 'edutainment' packages, desktop tutorials, open learning, publications, games, etc. DTTB offers the opportunity for this technology to become an integral part of broadcasting services with DTTB. The DTTB receiver might also serve as a common wide-screen window to the 'information superhighway'.

The availability of dual PAL/DTTB television receivers to consumers wishing to gain early access to new DTTB services may be desirable. This could ensure consumers who converted to DTTB early in the transition period are not disadvantaged by their inability to access PAL programming, which, if different in part to DTTB services, might continue to be attractive to some consumers. Set-top converters are considered to be a poor substitute for integrated digital receivers. Although they might have limited application they cannot provide consumers with the digital viewing experience possible with a new generation DTTB receiver.

The receiver manufacturers must be encouraged to design and manufacture new generation, fully integrated and intelligent receivers, which can be operated by a single uncomplicated remote control unit.

The new generation receiver should desirably be able to receive and automatically process, all available services including existing PAL, pay TV, multi-program services, multimedia and new DTTB services without the need for another 'set-top' box and associated remote control. The viewer would then be able to simply select the particular service required and the receiver would intelligently process the selection and display the appropriate service on the screen in the correct format. Ideally the new generation receiver should be of a true 'flat wide-screen' design which occupies less floor area than currently available units.

Ideally the intelligent receiver should be of a modular design to enable the consumer to purchase the receiver with the level of service options initially required but with the knowledge and confidence that the receiver can be upgraded at a later date.

Obviously the intelligent receiver must also be affordable if rapid acceptance of DTTB and associated services is to be achieved. As mentioned earlier, there are constraints

on what features can be reasonably accommodated in the receiver so alternative technology might need to be explored for connecting the range of future services to the home so that the consumer is able to receive all services, irrespective of delivery means, on a receiver without the need for separate set-top converters for each service.

Compatibility with Computer Display Technology

The utilisation of high resolution computer monitors for the display of HDTV services was raised. The respondent wished to point out there already exists a significant inventory of high resolution computer monitors throughout Australia which could in the near future be capable of receiving and displaying HDTV services.

From the perspective of both broadcasters and consumers it would be an advantage to ensure that new generation television receivers offer display compatibility with computer generated graphics and full motion video. Through this medium the possibility exists for a true wide-screen video interactive home entertainment display centre. The DTTB systems being researched bring closer the possibility of a convergence of PC technology and television broadcasting.

Costs of introduction

Some contributors made the point that non-metropolitan broadcasters have a major difficulty in financing a change to DTTB, particularly at this time. Transmission costs represent a large proportion of their total costs because of the large number of transmitters and translators necessary to serve their more sparsely populated licence areas. For many, the costs associated with equalisation of regional commercial television are still a major burden and an early implementation of DTTB in their areas would be financially difficult to justify. Some believe that the high costs of duplicating their networks, with little prospect of early return, needs to be fully factored into the planning for DTTB.

Similar concerns have been expressed about the high cost of re-equipping studios. This cost will be borne by the program producers and originators.

Some better costing information is likely to emerge from the USA as it moves to perhaps be the first to start digital terrestrial broadcasting.

Simulcasting or New Programming?

One of the most interesting questions for the consumer is how programming might be affected if a second channel is assigned to existing terrestrial broadcasters

In the U.S., the Federal Communications Commission (FCC) has made a preliminary decision to require simulcasting of the same pro-

grams on both the new and the old channels. Initially, a 50% simulcasting requirement will be imposed seven years after the application/construction period ends and a 100% simulcasting requirement two years later (i.e. at nine years).

Initial flexibility with the simulcast requirement is allowed to provide 'sufficient time and flexibility to establish, as a technical matter, a distinctive [Advanced Television] format in the marketplace'. This could be done, for example, by utilising programs produced in film and directly converted to ATV, or programs originally produced on ATV. The FCC stresses, however, that the broadcaster should not 'develop a second programming service' in light of the FCC's intention of 'reclaiming the reversion channel as soon as possible'. At the nine year mark, 100% simulcasting is required predominantly to 'protect consumer investment in NTSC equipment, while at the same time promoting ATV implementation'. Obviously this preliminary decision by the FCC did not contemplate the question of multi-program options within DTTB.

One of the key questions in relation to a simulcast model centred on whether there would be sufficient incentive for consumers to switch over to the digital service if there are no discernible differences in the service provided, except for some technical improvements to signal quality and reception. Although the cost of new equipment is likely to play a role in the rate at which digital technology is adopted by consumers, without other incentives to switch over the transition period might become unnecessarily protracted.

In recognition of this fact, some have proposed that new programming on the digital channel is a valuable option for providing additional incentive for consumers to switch to digital. In Canada, for example, it has been proposed that the broadcaster have the option of providing a digital service based upon different programming. In the UK, the ITC has also highlighted that it 'would probably be necessary to allow some distinction in the two program services, with more attractive programming being introduced on the digital service'.

In Australia, some combination of the two approaches might provide the greatest benefit for the consumer.

The flexibility to provide new and/or more attractive programming on the digital channel could also be crucial in attracting consumers to the new technology and ensuring DTTB is viewed as a positive development for free-to-air television. This might be particularly important in the interim period, if set-top units are needed because these will not be able to capture for the viewer the benefits of better picture quality available from a new DTTB receiver.

The Way Ahead

Critical Success Factors

The introduction of DTTB will require both consumer and broadcaster support. Consumers and broadcasters both need to invest in appropriate hardware, broadcasters need to provide program material that viewers will regard as adding substantial value to the package of services they now receive. While some existing program material will be enhanced by the improved capacity to deliver studio quality images to viewers this alone is unlikely to be sufficient to entice viewers to make the investment in new receivers.

A single broadcast standard will be necessary in order to avoid confusion for viewers. The standard selected should as far as practicable be in step with, if not the rest of the world, a major user block from which Australia will be able to benefit from the high costs of research and development involved in the transition. Australian broadcasters will also want to be able to market Australian production elsewhere with as few technical obstacles as possible.

Standard setting should in the first instance be a matter for resolution between broadcasters, manufacturers and consumer interests. Government can and should play the role of facilitator rather than try to 'pick winners'. There are clear examples of the failure of Government directed standards in HDTV, and clear indications of a much more successful and practical outcome in the digital terrestrial television standardisation approaches being undertaken in Europe and the USA. These are essentially broadcasters and manufacturer driven, but with strong co-operation from Government as a participant in the process.

Legal and Policy Issues

Government will need to consider whether the present legislation is adequate to meet the legal and policy issues upon which digital terrestrial television will impact. For example, how will existing broadcasters participate in the introduction of the service? Will multi-program options be permitted? If an existing broadcaster is entitled to simulcast to what extent will the broadcaster be permitted to place innovative new program material on the digital service to differentiate it from the PAL service? To what extent will digital broadcasters be obliged to broadcast 'high definition' material *vis a vis* multi-program standard definition material? What part of the digital capacity may be used for non-broadcast applications such as digital data broadcast?

Standards

Further serious consideration of the appropriate standards for an Australian system will flow from the work currently reaching maturity in the USA and in Europe. Once further technical performance characteristics of these systems are established from field studies, then further detailed work can be undertaken on Australian spectrum studies. The studies undertaken to date suggest that the system choices should not be substantially driven by spectrum concerns; However, the system options certainly do have some implications for spectrum planning work, particularly in terms of what types and how many services might be established. From that will flow information that might be essential in the determination of appropriate policy and legislative directions.

Next Steps

Comments on this report are invited, and the ABA DTTB Specialist Group will be undertaking further work associated with development of the directions already established and reported here. The Specialist Group will also be reviewing its directions and strategies in the light of commentary received in response to this report. A preliminary report to Government will be made following consideration of responses to the report.

Appendices

1. ABA DTTB Specialist Group Terms of Reference
2. DTTB Issues and Options Discussion Paper
3. Synopses of Submissions Received on Discussion Paper
4. Glossary
5. MPEG Digital Coding - Explanatory Paper

AUSTRALIAN BROADCASTING AUTHORITY (ABA) SPECIALIST GROUP - DIGITAL TERRESTRIAL TELEVISION BROADCASTING (DTTB)

Terms of Reference

INTRODUCTION

The Australian Broadcasting Authority (ABA) is required to plan the broadcasting services bands and to advise the Minister on technological advances and service trends in the broadcasting industry. In this context, the ABA needs to consider the planning and system development implications of digital terrestrial television broadcasting (DTTB) technology, which is emerging as the next major development in broadcast television.

Major work on DTTB is being undertaken in the USA and Europe, and the International Radio Consultative Committee (CCIR) of the International Telecommunications Union (ITU) has appointed a special Task Group to study international standardisation of this technology and has other groups studying various aspects of the technology such as studio equipment, transmission, and planning. Work on the digital coding of television pictures is being studied by both the CCIR and the International Electrotechnical Commission/International Standards Organization (IEC/ISO), through its Motion Picture Experts Group (MPEG). Australia participates in both groups through its membership the CCIR, and through Standards Australia, a member of the IEC/ISO.

DTTB work in Australia is currently being undertaken by a number of specialist groups, including the Australian study groups of the CCIR concerned with broadcasting, Standards Australia, the specialist engineering groups of the Federation of Australian Commercial Television Stations (FACTS), and in the ABA Planning Division. None of these groups is resourced or organized to draw together the various elements of the technology in a way which will stimulate open public debate on the technology, nor to distil the technology options into a form that will allow properly focused consideration of the national policy

and systems standards for a future DTTB system. Accordingly, the ABA has convened a joint industry and government specialist group to develop discussion and information papers for wide public exposure to stimulate open debate. The results of this process will assist the ABA to formulate its advice to the Minister and its decisions on the planning of the broadcasting services bands. They will also contribute to the national policy debate.

The Specialist Group on DTTB of the ABA will not duplicate the work of the individual specialist groups working on this topic. Rather, the Specialist Group will draw on the work of the other national groups and establish a productive dialogue with them so as to ensure effective coverage of the topic, efficiency of studies, and information sharing. Where appropriate the specialist group will draft possible ABA contributions to these groups.

The Department of Transport and Communications has asked that the specialist group take over the work of its Committee on the Australian Television System (CATTS) which has been in operation for several years under the administrative arrangements existing prior to the formation of the ABA. The Department has indicated that it will arrange consideration of the overall policy issues relating to the introduction of digital television, when developments have reached the stage that such consideration is warranted. Such arrangements will involve the ABA and provide for input from the Specialist Group. The DTTB Specialist Group has accepted to absorb the technical work of CATTS but will not address the issues of harmonisation or program production issues.

FUNCTIONS

The functions of the Specialist Group are to advise the ABA on:

1. the technical systems standards and planning implications of DTTB technologies under development world wide; and
2. the broadcasting spectrum planning impact of candidate DTTB technologies, with particular emphasis on their integration into the existing broadcasting services bands.

In performing these functions the group will:

a. identify desirable national objectives for DTTB in Australia;

b. evaluate candidate technologies against the objectives;

c. formulate proposals for contributions on systems and planning aspects of the development of international standards for DTTB (to be submitted through the ASG 10-11 of the CCIR, Standards Australia, etc. as appropriate in accordance with the appropriate national policies for submission of such proposals);

d. contribute to the formulation of national policy options for DTTB by:

   preparing 'plain english' reports on technical, spectrum, standardisation, industry, and economic aspects, and public interest aspects of DTTB;

   providing advice to the national policy group (to be estabished by the Department of Transport and Communications) (when established),

on the technical and industry implications of national policy options under consideration.

e. formulate recommendations to the ABA on the development of broadcasting systems standards for DDTV (systems standard setting responsibilities are expected to involve the ABA, DTC, SMA, the Minister and possibly Standards Australia - formal arrangements are still under discussion);

f. formulate national options for integration of existing and DTTB systems and the eventual full transition to DTTB;

g. draft discussion and information papers for possible publication by the ABA to encourage wider debate, to disseminate information that represents widely accepted and current knowledge of national and international experts on DTTB;

h. report regularly to the ABA on its activities; and

i. establish a work and reporting program for ABA endorsement.

ORGANISATION

The Specialist Group will be convened by the ABA which will provide chairman and secretariat for the group. The ABA will establish and approve terms of reference for the specialist group on advice of the group. The ABA has appointed Director Planning of the ABA to chair the group.

Methods of Working

The Specialist Group will undertake the bulk of detailed work through working parties. The specialist group will appoint convenors of the working parties, approve work programs, terms or reference, and reports of the working parties. The Specialist Group may establish standing and ad hoc working parties. The working parties should, where appropriate, serve as a liaison between the Specialist Group and other national groups working on DDTV.

Close working arrangements and co-ordination is to be established between the group, CCIR ASG 10-11, Standards Australia, and the FACTS Engineering Committee.

Membership

The following groups have been invited to participate in the specialist group:

Australian Broadasting Authority
Planning
Research
Policy
Department of Transport and Communications
Broadcasting Policy
Spectrum Mangement Agency
Communications Laboratory
National Transmission Agency
Federation of Australian Commercial Television Stations (FACTS)
(a cross section of industry experts have been nominated)
Australian Broadcasting Corporation
Special Broadcasting Service
Community Broadcasting Association of Australia

Manufacturing and Other Interests:
Broadcast Communications Limited New Zealand
Philips Industries Australia
Manufacturers, representation from Japan and USA if suitable local representatives who can contribute can be identified

Other experts may be invited to participate as appropriate in the working groups that will undertake the detailed studies under direction of the specialist group. They also have the opportunity to contribute through the other national expert groups, and through comment on the documents of the specialist group.

Meetings

As far as possible, the group will endeavour to conduct its business by correspondence and working parties. It will meet at least twice per year and more frequently as developments and the need to consider the work of working parties, or other issues.

APPROVAL

These Terms of Reference were endorsed by the first meeting of the specialist group held on 26 May 1993. They were approved by the ABA in June 1993. The group may recommend to the ABA at any time, variations to these terms of reference.

Membership

The initial membership of the specialist group was as follows:

Mr Roger Barrett, Engineering Director (ATN), Seven Network, Sydney;

Mr Richard Barton, Deputy General Manager, Federation of Australian Commercial Television Stations, Sydney;

Mr John Begini, Controller, TV Technical Services, Australian Broadcasting Corporation, Sydney;

Mr Robin Blair, Manager Design, Telecom Broadcasting, Melbourne;

Mr Wayne Dickson, Engineer Transmission, TEN Network, Sydney;

Mr Ian Goodwin, Broadcast Communications Ltd, Wellington, New Zealand;

Mr John Goozee, Policy and Coordination Branch, Special Broadcasting Service, Sydney;

Mr Peter Gough, Group Chief Engineer, WIN Television, Wollongong, NSW;

Mr Robert Greeney, Director Engineering, Australian Broadcasting Authority, Canberra;

Mr Alan Hayes, Manager, Transmission Planning, National Transmission Agency, Canberra;

Mr Ron Higgins, Chief Engineer, Northern Rivers Television, Coffs Harbour, NSW;

Mr Dilip Jadeja, Manager Transmission Policy, Australian Broadcasting Corporation, Sydney;

Mr Colin Knowles, General Manager Planning and Corporate Services, Australian Broadcasting Authority, Sydney;

Mr Keith Malcolm, Manager Communications Laboratory, Department of Transport and Communications, Canberra;

Mr Frank Reilly, Broadcasting Policy Division, Department of Transport and Communications, Canberra;

Mr Bruce Robertson, Executive Vice President Engineering, Nine Network, Sydney;

Mr Terry Smith, Director Planning and Development, Special Broadcasting Service, Sydney;

Mr Geoff Smith, OPTUS Communications Ltd, Sydney;

Mr Jake Vanderstock, Network Chief Engineer; Prime Television (Southern), Canberra;

Mr Peter Webb, Deputy Chairman, Australian Broadcasting Authority, Sydney;

Mr Allan Williams, Special Projects Manager, Philips Consumer Products, Sydney;

Mr John Yip, Executive Engineer, Transmission Development, ABC-TV, Sydney;

Mr Eddie D'Amico, Planning Branch, Australian Broadcasting Authority, Canberra.

DIGITAL TERRESTRIAL TELEVISION BROADCASTING IN AUSTRALIA-

Issues and Options

In the relatively short history of television in Australia, a dominant part of our way of life, there has only been one substantial change - the addition of colour in 1975.

While colour pictures made watching television more enjoyable, viewers had to invest in new television sets and broadcasters had to invest in new studio equipment in order to take advantage of the enhancement. Any further change which involves a large expense for both viewers and broadcasters requires careful consideration. For the public and broadcasters to decide that investment in new equipment is worthwhile, such a change will need to offer a similar major enhancement of television services.

Technological developments in the last decade have created an opportunity to consider such a change. There is potential to offer appreciable improvements in signal quality while, at the same time, making it possible to increase the number of programs available to viewers.

The new technical methods are grouped under a general term, digital terrestrial television broadcasting (DTTB). Several possible systems are in active development in North America and Europe, each having different advantages and disadvantages for application in Australia.

Improvements over the current PAL broadcasting standard used by Australia may include:

- higher quality pictures and sound, allowing cinema quality viewing to home audiences, with large, wider screens;
- greater portability, allowing easy relocation of television sets around the house and outdoors, and even allowing reception in moving vehicles;
- consistent quality of reception across the area which a television

station operator is licensed to serve, with freedom from current annoying problems like ghosting, interference and noise (snow);

- greater number of program channels, depending on the quality required;
- less spectrum may be required for television broadcasting in the longer term;
- flexibility in daily programming for broadcasters to move from very high quality pictures and sound for prestige programs like sport and movies, to four or more program channels where the technical quality is less important than program variety;
- improved capacity for providing access to sound and ancillary services such as closed captions for the hearing impaired, audio description channels for the sight impaired, multichannel sound which could allow audio in several languages to accompany pictures, stereo or surround sound, teletext, and other data services.

While it is possible that existing outdoor television antennas will be able to be used by householders to receive DTTB signals, they will need to buy a new television set or a set-top signal converter. Any change will need to ensure that the public continues to receive the currently available television services on their existing sets for many years. Estimates indicate that DTTB would not be a significant challenge to current viewing patterns until into the next decade.

This discussion paper aims to introduce the issues related to DTTB to Australian television audiences, so that all views can be canvassed.

Background

Recent developments in digital technology have allowed us to re-examine the delivery of broadcast television services to viewers in Australia. The Government has decided that satellite-delivered pay TELEVISION services should use digital transmission techniques which offer, among other benefits, more channels from which to choose.

In North America and Europe, satellite digital transmission developments are being paralleled by studies into using similar technology to improve the performance and spectrum efficiency of terrestrial broadcasting and the performance and channel capacity of cable.

In the USA, the decision has been made to introduce a new, technically advanced, television broadcasting system. This will be achieved by giving existing broadcasters first preference for advanced television channels which would be available within the existing broadcasting bands. This additional channel would allow broadcasters to develop public interest in advanced television and assist in the total transition to the new system. Eventually, these broadcasters must give up their current channel which will also become available for advanced television.

In Europe, the investigation of digital technology for television broadcasting began later, partly because the Europeans initially concentrated on trying to improve analog technologies like MAC and PAL PLUS. The Europeans have now largely abandoned that work and are concentrating on digital technology.

Satellite digital television is expected to be available in Europe by 1995, with terrestrial digital television available around 1999. The Europeans plan to build compatible systems for all digital delivery modes - satellite, terrestrial and cable.

The ABA has been monitoring digital television developments in the USA and Europe and considers that they will have implications for planning broadcasting services in Australia. The ABA has established a specialist group of interested experts to examine options for a digital television broadcasting system which will best suit Australia's consumer and broadcasting needs into the next century. The move to digital transmissions is inevitable, but the Specialist Group is trying to provide direction for the introduction and implementation of digital services, taking into account the views of the public about the relative importance of the various issues involved.

Public Comment Invited

The ABA's DTTB Specialist Group includes representatives from government, the broadcasting industry and manufacturing interests.

While the specialist group will provide the ABA with valuable advice about DTTB, the ABA also considers that there are important social and technology issues and business interests which may only emerge if views are canvassed from the public as a whole. This discussion paper is intended to provide the basis for these contributions.

The ABA's Specialist Group has identified several key points related to DTTB technology and the planning issues which accompany its introduction, which should be addressed. The key points expose the implications for broadcasting-related services, such as program production, as well as implications for other communications services and the future use of the radiocommunications spectrum for broadcasting services. They also point to the policies that will need to be developed to ensure that change is handled as smoothly as possible.

The key questions identified by the ABA's Specialist Group are:

- HDtelevision and/or multichannel?
- Termination of PAL services?
- VHF and UHF?
- Channel spacing?
- USA or European standards?
- Relevance of pay TV standards to DTTB?
- Separation of television services into discrete licence areas?

The ABA is seeking comments about the issues raised in this discussion paper. Matters not addressed in this document may also be raised, but should have a definite relationship to DTTB.

HDTV and/or Multi-Channel?

Whatever DTTB system is chosen for Australia, it should ideally be flexible and allow enhancements. There are significant and incompatible differences between digital transmission systems being developed by the USA and Europe, where the main work on digital transmissions systems is being undertaken.

Therefore, should Australia:

- follow the USA recommendations of a predominantly HDTV scenario for DTTB, with multi-channel for satellite or cable delivered services; or
- align with the European proposals, which promote the terrestrial, satellite and cable delivery of a range of standards of service, from sophisticated HDTV to low definition television, as well as multi-channel services, to a commonly available television set?

Australia's choice will need to take account of which scenario provides the greatest benefit for broadcasters and the viewers alike.

The introduction of DTTB is likely to enable improvement in picture quality in three distinct and significant areas:

i) elimination of ghosting and other interference phenomena;

ii) introduction of wider screens and higher resolution pictures; and

iii) the capacity for picture resolution to be varied to suit the program being screened.

Termination of PAL Services?

DTTB will need spectrum to enable it to be introduced in Australia. One possibility is to use currently unused - or unusable - parts of the terrestrial television broadcasting spectrum. Beyond this, additional spectrum for DTTB could be obtained by replacing existing television services with DTTB services. This would cause considerable upheaval in the short term so, at this stage, it is primarily seen as a possibility for the longer term.

There is a huge investment in infrastructure to support Australia's television broadcasting system, known as PAL. The current PAL television set population in Australia is about seven million and there are also several million VCRs. Television sets have a typical, useful life of between 10 and 15 years. As long as there is a sizeable population of PAL sets in viewers' homes, termination of PAL services will be very difficult. The introduction of DTTB will require a period where parallel transmission, of both PAL and DTTB signals, is required.

The only comparable examples of introducing a new, but incompatible television broadcasting standard was the change from 405 line to 625 line television in the UK and the change from 819 line to 625 line television in France. The changes were timed to coincide with the introduction of colour television but parallel broadcasting of both standards was maintained for 20 years in the UK, and longer in France.

How soon PAL services could be terminated depends on how soon DTTB is introduced and how quickly a large DTTB television set population can be established. That, in turn, depends on set prices, quality of service, the number of channels and the availability of attractive programs.

In the US, it is proposed that DTTB services would start in unused or unusable channels and be broadcast simultaneously with existing NTSC services. Every existing broadcaster will be allocated a channel for DTTB delivery, and both of these channels will be required to carry the same programming material for a period of 15 years. By that

time, the population of DTTB television sets is expected to have reached a level that would allow termination of NTSC services. The vacated spectrum could be used for more DTTB services, but could also be used for other, yet to be determined, purposes.

On the other hand, Canadians (who expect to follow a similar simulcast option) have indicated that an enforced termination of NTSC analog services is not desirable. They believe that the decision should be based upon competitive market forces and should be made by industry organisations on a market by market basis.

European countries have yet to decide how DTTB will be implemented.

VHF and UHF?

The decision to use both VHF and UHF television bands, or only UHF, for DTTB will be based on the technical requirements of the DTTB standard ultimately adopted by Australia and the limitations imposed on DTTB planning by past broadcasting planning practices. The need to provide for both PAL analog and DTTB during an extended phase-in period also imposes technical constraints on the planning of DTTB.

Of the VHF television channels currently used in Australia, channels 0, 1 and 2 may not be suitable for DTTB. Channels 3, 4 and 5 are also unsuitable because they straddle the spectrum set aside, internationally, for FM radio. The remaining VHF channels (currently 6 to 11, but channel 9A and 12 may also be considered as they are expected to be available for broadcasting purposes in future years) may be suitable. On the basis of overseas studies, UHF channels 28 to 69 will be suitable for DTTB.

It is likely that the technical performance of currently used outdoor VHF and UHF antennas will be adequate for DTTB. To minimise disruption to the domestic television systems, it is desirable that DTTB services are introduced in spectrum where the existing PAL services are now found. In Europe, it is possible that DTTB will be transmitted exclusively in the UHF television bands. In the USA, the FCC has already mandated the use of UHF television bands for DTTB.

There are major economic considerations associated with DTTB. The majority of DTTB television sets will be built to receive only signals transmitted in the UHF bands, as a consequence of European and American decisions. If Australia decides to use both VHF and UHF television bands for DTTB, television sets will have to be deliberately designed to meet this need, and the costs will be higher as a consequence.

Channel Spacing?

The use of 8 MHz spacing between UHF television channels in Europe allows the adoption of 8 MHz wide DTTB channels. The USA uses 6 MHz spacing between channels and is moving to produce a standard specifying 6 MHz wide channels for DTTB. The difference in channel spacing used in Europe and the USA is a major consideration in deciding what DTTB standards are likely to be adopted by Australia. It is unlikely that a system will be specifically developed for

Australian 7 MHz channel spacing because of the limited market for specialised television sets. For Australia, then, retaining channel spacing of 7 MHz may not be a sensible solution.

In the case of the 8 MHz European system, there may be difficulties in the adoption of an acceptable Australian national television channel plan without some disruption to current channel allocations. This certainly appears to be the case in the VHF television bands but may be a less of a problem in the UHF bands. Despite these potential planning difficulties, channel spacing based on 8 MHz could lead to a DTTB system of superior performance and, in the longer term, improved spectrum productivity through the use of same channel repeaters and single frequency networks.

A USA 6 MHz based standard could be adopted for use in Australia in both the VHF and UHF bands. Australian 7 MHz channel spacing could readily accommodate the 6 MHz DTTB signal. However, there needs to be serious thought about what could or should be done with the 1 MHz of spectrum 'left over'. The merits of adopting this channel spacing include the early availability of affordable television sets and earlier introduction of DTTB services.

A modified European or USA standard, adapted to suit Australian 7 MHz channel spacing, if that option becomes technically possible, could be used in either VHF or UHF bands.

USA or European Standards?

At the moment, the Australian television industry is aligned, at least technically, with Europe. If television broadcasting in Australia were to remain analog, then this situation would probably continue. However, the imminent introduction of digital technology for Australian television opens the door to interesting options unable to be considered previously, namely the ability to consider USA-based standards.

The compatibility problems created by the two standards, NTSC and PAL, and the need for expensive conversion processes are no longer major issues.

With digital technology, Australia is able to reconsider which standards to align with, not only on the grounds of technical merit, but also because there may be economic benefits in favouring one system over the other.

The availability of a reasonably priced, dual-standard PAL/DTTB television set will need to be assessed.

Relevance of Pay TV Standards to DTTB?

Section 94 of the *Broadcasting Services Act 1992* provides that the holders of subscription television licences A and B should agree an appropriate standard for full digital transmission for pay TV services. The Minister will then declare the chosen standard following consultation with OPTUS. If the two licence holders are unable to agree on a standard by 1 March 1994, the Minister must make the decision in consultation with the parties

involved, having regard to any relevant international standards. However, pay TV is the only area where procedures for determining standards for broadcasting systems have been set down in legislation.

The procedures for selecting pay TV standards is not expected to lead to complications in selecting DTTB standards. Therefore, a DTTB standard could be set which reflects evolving world standards, but is adapted to suit Australian requirements.

Separation of Television Services into Discrete Licence Areas?

In Australia, television operators provide services within defined areas called licence areas. There are several hundred licence areas, both large and small.

Television broadcasting in Australia has been planned to provide viewers with access to six television services through networks of terrestrial transmitters, though, in many areas, the fifth network (SBS) and the sixth network may not be operating.

Some operators provide programs across the nation. Others do not and most commercial television services make provision for local news, advertising and community announcements. The insertion of local programs is facilitated by arrangements between major metropolitan-based networks and their regional affiliates and is made possible by using translators to broadcast the programs originating from main transmitters. Each translator broadcasts on a different frequency from the main transmitter and from each other.

One option for DTTB in Australia involves using single frequencies for each television service. In other words, the whole of Australia could become a single licence area for some services. Another possibility enables single frequency networks to cover smaller geographic areas such as a State or a Territory.

While there may be benefits in the creation of a national licence areas using a single frequency, the capacity for local programming to be inserted would be negligible. Similarly, the insertion of local advertising would not be possible. The ability to have both targeted and localised advertising has benefits for audiences and advertisers. The retention of areas that could be independently programmed within a licence area would help preserve a measure of localism, or at least regionalism, in both programming and advertising.

The commercial, economic, social, cultural and political implications of adopting the concept of national single frequency services need to be examined.

SYNOPSES OF SUBMISSIONS

Ref: WG-SO-104

SUBMISSION BY
TRUE VISION 3-D PTY LTD,
CLAREMONT WA

True Vision claims to have developed a 3 dimensional television system which could use existing broadcast infrastructure for 3 dimensional television and will also be suitable for HDTV. Proposes new broadcasting standards should include a section for 3 dimensional television.

REF: WG-SO-105

SUBMISSION BY
DR. DAYLAL ABEYASEKERE,
SCHOOL OF ELEC. & ELECTRONIC SYS. ENG, QUEENSLAND UNIVERSITY OF TECHNOLOGY

The submission draws attention to the technological and economic advantages of early adoption of the USA digital system allowing development of a receiver manufacturing capacity in Australia. There are prospects of integrating this development with the other converging technologies to re-establish customer equipment manufacturing in Australia.
On specific questions :

- **HDTV or Multi-channel?**
  Multi-channel important.
- **Termination of PAL Services?**
  Elimination of PAL broadcasting and receivers could take more than a decade.
- **USA or European Standards?**
  'Early adoption of USA HDTV standards would offer significantly greater technological opportunities to Australians.' Particularly in reviving consumer product manufacturing.
- **Relevance to Pay TV Standards?**
- 'Procedures for selecting pay TV standards can and should be separated from those for DTTB/HDTV broadcast standards.
- **Discrete Licence Areas?**
  'The ability to broadcast local program content and targeted/local

advertising should be the most important criterion...'

The submission includes the following recommendations:

- The adoption of DTTB/HDTV has far wider potential benefits than the provision of additional channels.
- As when colour television was first introduced in the mid 1970s in Australia, incompatibilities necessitated simulcasts for almost two decades. A similar requirement will apply with the introduction of HDTV.
- HDTV receivers to USA standards will be UHF limited in the first instance, and will be more economic than any VHF/UHF combination. Initially UHF limited broadcasts for HDTV will be an economic necessity for Australia.
- Channel spacings to USA standards will bring immediate bandwidth conservation advantages which will need new channel definitions. Any excess bandwidth can be reused for other purposes when so required.
- Fully digital USA standards are more forward looking and are therefore conducive to the development of technical leaderships and manufacturing revitalisation in the communications and computer manufacturing sectors. In order to exploit relevant advantages, early decisions will be required on entry of Australia into DTTB/HDTV scene. Delays will be damaging.
- Pay TV broadcast standards can and should be treated independently of DTTB/HDTV broadcast standards.
- Licensing issues should also be treated separately from DTTB/HDTV broadcast standards issues and options.
- DTTB/HDTV issues and options should encompass benefits to technological and manufacturing environments of Australia.

Ref: WG-SO-106

SUBMISSION BY
PETER TWOMEY,
SHEPPARTON

The submission notes that the full cost of DTTB will ultimately be born by the public and will involve substantial imports of equipment.

On the specific points raised in the discussion paper:

- **HDTV and/or Multi-channel?**

  The advantages of HDTV are limited to large screen projection systems.

- **Termination of PAL Services?**

  There is no valid reason to suggest a termination date. Existing PAL transmission equipment has a potential life of 25 years.

- **VHF and UHF?**

  If possible, it is desirable for all DTTB to be in UHF.

- **Channel Spacing?**

  Australia should revert to 8 MHz channel spacing.

- **USA or European Standards?**

  Premature to decide now. We should wait for regular DTTB services to commence in both USA and Europe.

- **Relevance of Pay TV Standards to DTTB**

  The method of subscription encryption should not result in

additional complexity or cost to open-broadcast DTTB receivers.

- **Separation of television Services Into Discrete Licence Areas?**

  It is necessary that the ability to have both targeted programs, and local retail commercials be retained for commercial television.

Reference is also made to the ability to introduce new low power restricted coverage services.

In summarising the submission suggests caution in introducing DTTB. Preferable to allow USA and European countries to solve the introductory technical problems.

Ref: WG-SO-107

SUBMISSION BY
ASSOCIATION FOR THE BLIND

This submission proposes that a future DTTB system should provide facilities for people with impaired sight or impaired hearing, and also for those with both handicaps. It argues that the need for such facilities has already been recognised in the ITU. (A copy of Document 10/67 from ITU-R WP10C was attached to the submission.)

The submission proposes two special sound channels for inclusion in the planning for future television services:

- For viewers with impaired sight, an augmented description or 'word picture' could be provided by a 'skilled describer' and carried on one of the special channels. (Note that the ITU-R document suggests a reduced bandwidth of 7 kHz or 3.4 kHz for this channel.)
- For viewers with impaired hearing, a special dialogue channel would carry reduced levels of background music or effects to allow adequate intelligibility.

Ref: WG-SO-108

SUBMISSION BY
R S DEMKIW

The writer of this submission suggests that not enough attention has been given to the possibilities of PAL PLUS. It is argued that a disproportionate amount of time has been spent on discussion of the optional wide-screen capability of PAL PLUS and the resulting letterbox format display on standard PAL receivers. Other advantages of PAL PLUS are given as the ability to transmit full bandwidth luminance and chrominance, ghost cancellation, digital stereo sound, a reduction of dot crawl and the ability to reuse existing transmitter sites and infrastructure.

It is argued that the success of digital television is dependent on the number of advanced receivers in the hands of the public at the time of its inception. However, the public would not buy digital receivers only on the promise of a digital service. The same receivers would therefore have to be able to demonstrate an improvement in picture quality even with PAL television transmissions.

The submission suggests that it may be desirable for Australia to adopt the American digital HDTV system because of the proportion of television programs from the USA, the potential market for Australian productions and the compatibility of the system with the USA and probably with the rest of the Asia-Pacific Region.

Other pressures acting towards the adoption of the USA system are

given as the likely penetration of USA-format satellite signals into Australia, the availability of pre-recorded home entertainment and the needs of the computer industry. The submission contends that, if Australia waits for the perfection of a European system, it is not likely that we would be able to obtain the equipment in time for the 2000 Olympics.

REF: WG-SO-109

SUBMISSION BY
MR M A [COURSEY]

The writer of this submission argues, from his viewpoint as a technical director with BOCP and TVOCP qualifications, that the DTTB system which is adopted should be the best technically achievable system with the minimum number of technical compromises. It is suggested that the first system available may not always be the best.

With regard to the question of channel spacing, the submission points out that there are many countries in Europe, Asia, Africa and the Middle East that use either PAL B or SECAM B with 7 MHz spacing. The writer predicts that a variation of the European standard would be devised for these countries, and this could include Australia.

Also on the subject of channel spacing, the submission notes that 'simplex repeaters' (presumably co-channel) could be used rather than multi-channel translators as used for PAL. It argues that the adoption of an 8 MHz DTTB system would then be less of a problem because of the smaller number of channels which would be needed.

The submission observes that even the best NTSC converted programs look inferior to a purely PAL sourced product and, whilst any difference in quality between a 6 MHz and 8 MHz DTTB signal may be less subjectively noticeable to the viewer, it is still desirable to adopt the system that utilises the minimum amount of data compression.

REF: WG-SO-110

SUBMISSION BY
SCREEN PRODUCTION
ASSOCIATION OF AUSTRALIA

General

It is difficult to forecast the consequences, from the introduction of digital terrestrial broadcasting, for Australian film and television producers with confidence. Perhaps a central question is whether there are any identifiable commercial issues flowing from the adoption of a particular standard that would affect the ability of Australian producers to sell into world markets. A further question is whether the vulnerability of the domestic television system to cross-border transmissions would vary with the digital standard chosen.

HDTV and/or Multi-channel

As there are likely to be many opportunities for signal transmission the alleged advantages of the European system do not seem to be as significant in the modern broadcasting environment. HDTV appears likely to be a more important facility for terrestrial television providers.

Termination of PAL Services

The removal of uncertainty in the market is a good argument for imposing a definite termination limit, even as far out as 15 years.

However, provision could be made for accelerated termination.

Channel Spacing

The 8 MHz requirement of the European standard would appear to necessitate spectrum re-allocation more immediately than the US 6 MHz, which merely frees up a bit of space. While there might be some discussion about what to do with the 'empty bits', this should not be seen as a cost.

USA or European Standards

In the absence of any information on commercial issues, flowing from the adoption of a particular standard, there would seem to be good reason for adopting a US rather than a European standard. Not the least of these reasons is the cost of equipment built to a US standard is likely to be cheaper.

Separation of Television Services into Discrete Licence Areas

If it is not possible to insert local material into a national licence area using a single frequency it might remove an important source of advertising revenue. This is an important and complex issue that probably merits more discussion.

REF: WG-SO-111

SUBMISSION BY
THE GOVERNMENT OF
WESTERN AUSTRALIA

General

It is crucial that other delivery mechanisms such as cable, microwave and satellite, and other major digital applications such as digital audio broadcasting, be considered along with terrestrial services during the planning stages of digital television broadcasting.

Viewers will be more receptive to meeting the costs of improving picture quality if these are complemented by improved program choice and quality.

HDTV and/or Multi-channel

The potential of digital television broadcasting to use less spectrum and hence free up space for more program channels is a major long term benefit which will be welcomed by both aspirant broadcasters and viewers. The ability to choose between broadcasting one HDTV service or additional channels will also be attractive to television broadcasters, despite costs for hardware changes and additional programming. Accordingly, the European model may provide more lessons than the American one. Nevertheless options such as cable delivered multichannel or satellite delivered HDTV should not be discounted.

Termination of PAL Services

Investigations into improving picture quality for current PAL transmissions should continue if the time before introduction of digital television broadcasting is prolonged.

It is imperative that the termination of analog services does not leave viewers without services. Parallel transmissions of PAL and digital television should occur for a minimum of 15 years. After ten years, a review should be undertaken to determine the penetration of digital sets and possible impediments to the closure of analog services.

VHF and UHF

Selection of a digital television broadcasting system for Australia should focus on a mix of terrestrial (VHF, UHF and MDS), satellite, and cable broadcast. It should also take into consideration other major digital applications such as digital audio broadcasting. However, major manufacturers of television receivers will focus their resources on supplying sets for digital models in the USA and Europe. To enjoy the economies of scale offered by these manufacturers, Australia's choice of digital television broadcasting must be aligned with particular determining aspects (e.g. frequency band) of these models.

USA or European Standards

System design for digital television broadcasting should aim to minimise the cost of television sets, even if this is at the expense of service providers having to pay more for transmission infrastructure. To enjoy the economies of scale offered by world television manufacturers, digital television in Australia must be aligned with digital systems of other world models. To ensure that the best possible digital television standard is selected for Australia, the ABA must allow time to review the outcomes of parallel research and development activities in other world markets.

Advantage should be taken of the revolutionary change from analog to digital to set standards which maximise equality of access by all Australians, regardless of their location.

Separation of Television Services into Discrete Licence Areas

The digital television system should readily permit local program (including local advertising) content and broadcast of all programs in the correct time zone. The preservation of separate licence areas within regions is an essential inclusion for Australia's digital television system.

REF: WG-SO-112

SUBMISSION BY
THE FEDERATION OF
AUSTRALIAN COMMERCIAL
TELEVISION STATIONS

General

While there will be substantial benefits to the viewing audience and for some sectors of industry from the introduction of digital terrestrial television, the costs of establishing new studios and transmission facilities for broadcasters will be very high. The key to achieving a successful introduction of digital services is to provide the necessary support and incentives to broadcasters to carry them through the transition period. In addition, unless the technology change is supported by the delivery of the main mass market programming it will have great difficulty gaining market acceptance.

HDTV and/or Multi-channel

A crucial element of gaining the full advantages of new digital opportunities for all media will be to encourage the rapid growth of DTTB receivers. Broadcasters will need to be able to interact with the market and adjust programming philosophies dynamically, as indicated by the audience acceptance. This flexibility will only be achieved by having

the ability to adjust between multiple program formats and advanced television quality, dependant on the program content and the most attractive presentation to the viewing audience. It is anticipated that the different terrestrial systems now in development will be based on an MPEG-2 platform with its inherent extensibility.

Termination of PAL Services

The removal of PAL services must be left for a market based decision. Conversion to UHF colour in the UK indicates that at least 20 years is likely. Denial of what is now essentially a universal service could only be contemplated when a sufficient population of DTTB receivers has been achieved and reasonable notice has been provided to the viewing public.

VHF and UHF

All licensees should be offered an additional licence in either VHF or UHF for the development of an advanced television service. For main metropolitan licensees there should be an additional VHF channel. For other areas a UHF channel may be more appropriate. Spectrum for the main metropolitan licensees may be best accomplished by using the current adjacent channels to provide effectively 14 MHz of spectrum.

Channel Spacing

As the introduction of DTTB would involve substantial expense to broadcasters with little or no prospects for an early return, the expense which would flow from any wholesale channel reassignments to other than a 7 MHz spaced plan, needs to be avoided. There is a distinct possibility that a modulation system compatible with the current 7 MHz spacing could be introduced without imposing a significant receiver cost penalty or system performance degradation.

USA or European Standards

It needs to be stressed that the choice of a television transmission standard can be generally independent of the studio/display standard. Given that premise then the choice of the transmission standard should take into account the more important criteria which will be influential in determining the successful introduction of DTTB. These factors should include:

- Availability of a system to meet any proposed implementation schedule.
- Anticipated receiver cost.
- Broadcaster implementation cost.
- System flexibility.
- Performance (quality).

Relevance to Pay TV Standards to DTTB

There is clear indication that the viable DTTB options will be based on MPEG-2 and there are good prospects for a DTTB system which has a high level of compatibility with video services delivered by other media, including Pay TV. Use of a common coding standard will allow the establishment of a basic interface to the main display which can be utilised by all media. The initial Pay standard will inherently depend on 'black box' converters to PAL. Additionally, it is likely that it will be chosen ahead of the full development of a useable DTTB standard.

While a sensible choice of a Pay TV system might take account of the most likely DTTB choice, the choice by the Pay TV licensees should not be a main element driving the DTTB selection.

Separation of Television Services into Discrete Licence Areas

For the reasons set out in the ABA discussion paper it is essential to ensure the preservation of separate service area structures to allow locally oriented programming and advertising.

REF: WG-SO-113

SUBMISSION BY
SONY AUSTRALIA LIMITED

The one and a half page 'Submission to Australian Broadcasting Authority re D.T.T.B. from Sony Australia' does not separately address the key issues of the ABA's paper, preferring to comment generally on digital television. The Sony submission is supportive of the introduction of DTTB as soon as practicable on the basis that it will provide 'a better television system for the people of Australia'.

In its submission, Sony comments on the impact that the new technology, particularly the introduction of 16:9 aspect ratio television sets, will have on television viewing habits. Further, it suggests that a market for hand held 4:3 LCD televisions will emerge which will need to be accommodated in an Australian DTTB standard along with the 16:9 HDTV application.

The Sony submission advocates the use of the 'taboo' channels alongside existing PAL services at an early date for DTTB.

REF: WG-SO-114

SUBMISSION BY
NETWORK TEN LTD

The Network TEN submission states that it is in 'broad agreement with the FACTS response' and raise three issues which are of particular importance to the network.

The three issues are outlined below.

- As a matter of principle Network Ten believes all existing free-to-air broadcasters be permitted to implement a digital service in addition to their analog service.
- As a matter of principle Network Ten believes Australia should adopt a DTTB standard best suited to Australia and resist hastily selecting one in order to meet some arbitrary timetable such as the 2000 Olympics.
- As Channel 9A is suitable for a 6 MHz wide television service only, the adoption of a 7 MHz DTTB system, Network TEN maintains, would have a detrimental impact on Network TEN's commercial viability because it would require the Channels 10 and 11 frequencies to be moved up 1 MHz. Further, in the event of the adoption of a 7 MHz system Network TEN sees the only feasible course of action would be to allocate Channel 11 to Network TEN for its digital service.

REF: WG-SO-115

SUBMISSION BY
PRIME TELEVISION LTD

Prime Television in its submission broadly supports the FACTS submission but raises a concern over what it believes to be the 'potentially serious adverse economic

impact of DTTB on regional [television] broadcasters'.

Under the 'Termination of PAL Services' heading Prime draws attention to what it sees as the potential inequitable economic burden on regional networks of replicating the existing PAL program distribution and transmission infrastructure for DTTB.

Additionally Prime Television supports the FACTS position on the preservation of existing service area boundaries as it sees this approach as the only means of 'ensuring a commercially viable "free" regional television industry'.

In a summary section, Prime Television submits a number of points which it believes need to be included in the current consideration of DTTB. These points are related to ways in which capital cost associated with the introduction DTTB may be offset by government subsidies.

REF: WG-SO-116

SUBMISSION BY
ABC TELEVISION

HDTV & A Multi-Channel

The system selected should have the flexibility to provide the broadcast in the HDTV and multi-channel mode of conventional PAL quality.

Termination of PAL Services

As there is a large domestic investment in PAL receivers which have a long life expectancy, the ABC prefers a retention of PAL transmissions of at least 20 years.

Additionally, the ABC favours of an early conversion of its technically inferior Channel 2 services in capital cities to a VHF Band 3 (Channel 12). This conversion is considered by the ABC as high priority, particularly in view of the possible DTTB development.

VHF OR UHF

The ABC's priority is to ensure that the services provided are of equal technical performance to those provided by the commercial channels. On this basis the ABC requires:

- PAL: Conversion of Band 1 (Channel 2) to Band 3 (Channel 12) in capital cities.
- DTTB: VHF Band 3 (Channel 11) if commercial channels are allocated a VHF Band 3 channel. Preference that both PAL and DTTB are selected to provide a contiguous pair.

Channel Spacing

The choice is dictated by technology availability, cost and timing. Given this, the ABC position is that the standard should comply with a 7 MHz solution.

USA or European Standards

Because of the PAL environment which will be with Australia for the foreseeable future, the adoption of a US based standard will be accompanied with many difficulties. The ABC, although not with a fixed position, leans towards a European standard solution if set pricing and timing become favourable. Clearly, the higher spectrum productivity which leads from the application of OFDM and the benefits that flow is an attraction unlikely to be available in the American standard. Despite this, the American system still needs to be given serious consider-

ation from the aspects of timing and cost of receivers.

Relevance of PAY TV Standard to DTTB

The selection of a suitable DTTB standard for Australia will have little relevance to the soon to be decided digital delivery standard for pay TV through the satellite. The only relevance is the adoption of the common MPEG1 coding, etc. standard for both systems. There is, however, potential application of the selected DTTB standard for delivery of pay TV service through MDS.

REF: WG-SO-117

SUBMISSION BY
SPECIAL BROADCASTING SERVICE

Introduction

The SBS submission notes that the flexibility afforded to free-to-air broadcasters by digital technology could be an important factor in their successful participation in the future broadband environment. The SBS also notes that conversion to digital technology will be at significant cost to broadcasters, in the case of SBS this will be at a cost to the tax payer. Therefore the primary consideration in determining the systems and standards for digital terrestrial television broadcasting should be the maximisation of the benefits of the new technology to the public.

HDTV and/or Multi-channel

The advanced television system determined for Australia should not be restricted to a single parameter such as high definition television, but should include provision for multiple programming, with the level of quality being varied to suit the demands of individual programming.

Termination of PAL Services

The most appropriate time to discontinue PAL will be determined by the rate at which the new technology television receivers are acquired by the viewing public.

The ABA should establish a consultative process with television broadcasters to take account of the response of the market place to the new technology and the impact on broadcasters who have to maintain separate transmission systems for PAL and DTTB. Adequate notice must be given to the public of the cessation of PAL services. Existing television broadcasters should be authorised to transmit parallel PAL and DTTB services until the penetration of DTTB receivers is such that PAL services can cease with minimum inconvenience to the public.

VHF or UHF?

The SBS' preference is that all existing television broadcasters establish their digital services on the UHF bands. However, the SBS recognises that continued use of VHF Band III may be necessary to accommodate DTTB in existing television spectrum to provide for a period of dual transmission of PAL and DTTB services. For the implementation of DTTB on the UHF band, the SBS requires adjacent channels to existing PAL services.

Channel Spacing

If at all possible, Australia should maintain the existing 7 MHz channel spacing to minimise disruption to existing broadcaster facilities. Future DTTB studies should look at the

possibility of using 8 MHz wide channels at 7 MHz spacing, noting that 6 MHz wide channels at 7 MHz spacing is acceptable.

USA or European Standards

While there could be future convergence of US and European standards, the SBS preference is towards the European systems because of their greater operational flexibility. It will be highly desirable to provide as much transparency as possible between transmission and production system standards.

Relevance of Pay TV Standards to DTTB

Likely to be of secondary importance to other issues. Common receiving equipment could be unnecessarily complex and expensive denying people choice; industry should possibly consider modular design concepts for digital equipment so that pay TV modules could be available for standard receivers.

Separation of Television Services into Discrete Licence Areas

The SBS notes that the European system lends itself to single frequency networks. Consideration needs to be given to this might be appropriate for use in Australia. Large metropolitan areas such as Sydney with its main transmitter and multiple translators might be an example of an area where an SFN could be created. The SBS also notes that the European COFDM modulation system provides a degree of immunity from multi path effects, and is capable of providing a higher quality signal within a coverage area when compared with other modulation methods. The SBS does not give a direct opinion on the use of discrete licence areas; as a national broadcaster, this is not an issue of significant concern to the SBS.

Commencement of DTTB

The SBS would propose a timetable for the testing and implementation of DTTB, with experimental transmissions by, say 1995/96, and full implementation by the 2000 Olympic Games.

Australian DTTB Trials

The SBS recommends DTTB trials be conducted as soon as possible to examine some of the issues discussed. The trials should involve the television broadcasters, the ABA, and the Department of Communications and the Arts and its Laboratory, and should be conducted in Sydney because it is possibly the most difficult metropolitan area to cover.

GLOSSARY

Australian Broadcasting Authority (ABA)
The ABA is responsible for planning and regulating broadcasting services in Australia. It gets its mandate from the *Broadcasting Services Act 1992*.

ABC
The Australian Broadcasting Corporation is a statutory corporation which operates non-commercial television and radio services across Australia. It is independent in program policy from the government of the day and is funded, in the main, by yearly appropriation from the Commonwealth Parliament.

Advanced television (ATV)
US digital HDTV system.

Analog
Currently available radio and television services are delivered using analog technology.

ASG10-11 of the CCIR
Australian Study Groups 10 and 11 of the International Radio Consultative Committee (which is currently referred to as the Radiocommunications sector of the International Telecommunications Union).

Aspect ratio
The ratio of the width of a television picture to its height.

ATSC
Advanced Television Systems Committee (United States).

CATTS
Australian Department of Transport and Communications' Committee on the Australian Television System.

CD
Compact disc.

CD-I
Compact Disc - Interactive. Compact disc containing digitally recorded video allowing interactive access by the viewer.

COFDM
Coded Orthogonal Frequency Division Multiples - a method of transmission of digital signals over a radiocommunications channel.

Digital
The way in which radio and television services will be delivered in the near future. Digital technology was first developed for computers, but it is being used, more and more, for other communications purposes, such as for telephones and for broadcasting.

D2-MAC
A particular standard based on the Multiplexed Analog Components (MAC) system developed for satellite broadcasting.

DTC
Australian Department of Transport and Communications.

DTTB
Digital terrestrial television broadcasting.

DVB
Digital Video Broadcasting refers to a European initiative in developing DVB standards and systems for digital video broadcasting

DVB-C
A standard developed by the European DVB initiative for cable network systems broadcasting digital television services.

DVB-CS
A standard developed by the European DVB initiative for the distribution of digital television services in buildings.

DVB-S
A standard developed by the European DVB initiative for satellite systems broadcasting digital television services in the 11/12 GHz band.

DVB-T
A standard developed by the European DVB initiative for digital terrestrial television broadcasting systems.

ERP
Effective radiated power (in a given direction) is the product of the power supplied to an antenna and its gain relative to a half-wave dipole in a given direction.

ETSI
European Telecommunications Standards Institute.

FACTS
Federation of Australian Commercial Television Stations.

Federal Communications Commission (FCC)
The USA's broadcasting and telecommunications regulator.

FM
Frequency Modulation.

High Definition Television (HDTV)
A television system having 16:9 aspect ratio and at least 1000 lines making up the picture (about double existing systems).

HD-MAC
A version of analog HDTV developed in Europe using MAC technology (see definition).

IEC/ISO
International Electrotechnical Commission/ International Standards Organisation.

ITU
International Telecommunications Union.

ITU-R
Radiocommunications Bureau of the International Telecommunications Union.

JPEG
The Joint Photographics Expert Group of the International Electrotechnical Commission/International Standards Organisation.

MPEG
Motion Pictures Expert Group is a joint technical committee of the International Standards Organisation and the International Electrotechnical Commission.

MPEG-1
A standard developed by MPEG primarily intended for digital storage applications of video and audio services. MPEG-1 was formally ratified in 1992.

MPEG-2
A generic standard developed by MPEG intended for use in a range of applications such as digital video storage, telecommunications and broadcasting. MPEG-2 was formally ratified in 1994.

MUSE
An analog HDTV standard developed by NHK, Japan.

Multiplex Analog Component (MAC)
A form of analog transmission signal coding used for satellite broadcasting.

Multi-channel
More than one program per transmission channel.

NTSC
The analog television system currently used in the USA, Japan, Canada and in some other countries.

PAL
The analog television system currently used in Australia, Europe and in some parts of Asia.

PAL PLUS
An enhancement to the PAL system, which provides a 16:9 aspect ratio.

PC
Personal computer.

SBS
The Special Broadcasting Service Corporation is an independent statutory corporation which provides multilingual and multicultural radio and television services. It is independent in program policy from the government of the day and is funded, in the main, by yearly appropriation from the Commonwealth Parliament.

SECAM
The analog television system currently used in France, the States of the Russian Federation, and some north African countries.

Set-top Signal Converter
Similar in appearance to a VCR. A converter translates a signal, e.g. satellite, broadcast in one system,

to a form suitable for use on an existing television set.

Simulcast
Broadcasting the same program on two or more channels.

Single Channel Networks or Single Frequency Networks or same channel repeaters
A network of transmitters that all broadcast on one channel/frequency throughout the area served by the station. The three terms are used interchangeably.

SMA
The Spectrum Management Agency, an Australian statutory authority responsible for management of the electromagnetic spectrum.

UHF
Ultra High Frequency. In Australia radiofrequency spectrum in the UHF band between 520 and 820 MHz is designated for broadcasting.

VCR
Video cassette recorder.

VHF
Very High Frequency. In Australia spectrum designated for broadcasting in the VHF band is located between 45 and 230 MHz.

VSB
Vestigial Sideband. A single carrier modulation method.

MPEG

Development of Digital Compression Standards

We have all heard promises of how recent developments in technology are about to make available to us a range of new and varied television and radio services. However try to understand some of these new developments in technology and one is bombarded with technical jargon. One of the terms that often appears in any report on future video and audio services is MPEG. This report explains the meaning of MPEG and outlines its important role in broadcasting technology development.

Before the functions of MPEG are discussed in detail, a basic understanding of what is meant by digital video and digital compression would be helpful.

Digital Video and Audio

In a digital video system, for example digital television, the video or picture information is coded into a stream of binary numbers (i.e. 0s and 1s). A digital television set receives this digital signal and extracts from it the video information. Advantages of using digital signals include its greater resistance to noise and interference and the fact that it can be easily manipulated by using advanced digital electronics.

Figure 1 shows a basic diagram of a digital television encoder and decoder. The encoder has as its input raw picture and audio data. The encoder converts the picture and audio information into digital information (i.e. 1s and 0s). The digital receiver, or decoder, receives this binary information and decodes from it the picture and sound information.

One of the great attractions of digital technology is that it offers the viewer or listener far better quality pictures or sound. The compact disc (CD) is a good example. Music on a CD is stored digitally.

A CD player reads the binary information from the CD and converts it to sound. As we all know, a CD player can produce better audio quality than what can be achieved by vinyl records which use 'analog' technology. Digital sound recording eliminates the 'hiss' and 'crackle' which is a feature of vinyl records.

Digital Compression

The 0s and 1s used to convey digital information are referred to as bits. The rate at which the bits are transmitted is known as the data rate or bit rate and is expressed in bits per second (bits/s). If no digital compression is used, a digital television service would require a bit rate in the region of 200 million bits/s to display smooth, 'real time' motion on the screen of a digital television set. This bit rate of around 200 million bits/s is rather high and it is difficult to deliver video services to the home at this rate. Through the use of sophisticated signal processing techniques, digital compression can reduce the bit rate of a digital television service to 10 million bits/s or less. It is far easier to deliver to the home a television service at this lower rate.

Similarly, impressive feats of compression are possible in the field of digital audio.

The reason that these dramatic bit rate reductions are possible is that video (and audio) sequences contain a lot of redundant information. Compression makes use of techniques that exploit this redundancy to reduce the total information and hence the total bits per second that has to be transmitted. An important consequence of making use of this redundancy is that although fewer bits are transmitted, those that are transmitted contain more concentrated information - and the consequences of errors to these bits can be more severe.

Spectrum for broadcasting television over the air waves is a limited resource. The lower bit rates achieved by digital compression make it possible to 'squeeze' in digital video services into the same amount of spectrum as that required by today's television.

MPEG

MPEG is an expert group that is working towards standards for digital video and audio compression. MPEG was formed in 1988 under the International Standards Organisation (ISO) and the International Electrotechnical Commission (IEC). The ISO has many working groups dedicated to formulating standards on various topics ranging from computers to freight containers.

MPEG seeks to define standards for the techniques used in achieving digital compression and the way the output binary information is arranged. MPEG, in the process of determining standards, has established formal liaison with groups within the radiocommunications and telecommunications arms of the International Telecommunication Union. MPEG also works in close co-operation with the Society of Motion Picture and Television Engineers, the Federal Communications Commission (USA) and the European Broadcasting Union.

Members of MPEG are experts from private industry, government bodies and research and educational institutions.

Standards Australia has established a local MPEG committee to review and monitor the work of the international MPEG group. All Australian representatives to international meetings of MPEG need to be accredited by Standards Australia. Australian MPEG representatives have included individuals from Telstra (Telecom), Siemens Ltd, the Department of Communications and the Arts, Monash University and the Australian Defence Force Academy.

The Need for a Standard

A standard for digital video and audio is essential to enable manufacturers to produce digital receivers. At present, Australian television sets conform to a standard called PAL-B and so do all Australian broadcast television signals. Hence any television set bought in Australia will operate here. Similarly a standard is required for digital video services, otherwise consumers could be faced with a chaotic situation where a different television set is required for each television service on offer. A role of MPEG, therefore, is to encourage world-wide standardisation of picture coding for digital television services.

In the world today there are three standards for conventional television, PAL, NTSC and SECAM. Since these standards are different and incompatible, it complicates the exchange of television programs between countries. MPEG provides an unique opportunity for one digital television standard to be adopted throughout the world and hence reduce problems with inter-working between countries.

Decision Making Process

MPEG usually meets four times a year; the exact number of meetings is governed by its workload. During these meetings, new proposals relating to digital video and audio services are considered and plans are drawn up for further work and the research that may be required for some of the new proposals.

MPEG meetings are held at various locations around the world. The first MPEG meeting in Australia took place in Sydney during March/April 1993.

After considerable consultation with its members and other interested groups, MPEG tries to formulate a draft standard for final approval. A new proposal, before it becomes an international standard, must proceed through a number of formal stages. The evaluation path from a proposal to a standard is shown in Figure 2.

MPEG Standards

There are two MPEG standards: MPEG-1 and MPEG-2. The MPEG-1 standard is completed, while the MPEG-2 standard is moving through the later stages of the standardisation process.

An MPEG standard has three basic parts; part 1 relates to video, part 2 to audio and part 3 to system standards. The latter describes the way in which binary numbers for video and audio are combined, or multiplexed, together to form one binary bit stream (refer to Figure 1). In the

case of MPEG-1, all the three parts were formally ratified in 1992.

MPEG phase 1 (or MPEG-1, as it is commonly known) was developed primarily for digital storage applications for video and audio services. A good example of such an application is the CD-I player. This is a soon-to-be released consumer product that will play CD sized discs containing moderately good quality digitally pre-recorded movies. MPEG-1 was originally intended to handle a bit rate of 1.5 million bits per second. However, due to its flexibility, MPEG-1 can successfully operate at higher bit rates.

Work on MPEG phase 2 (or MPEG-2), commenced in 1991. MPEG-2 builds on the achievements of MPEG-1 by being a more generic and flexible standard. It is expected that MPEG-2 will be used for applications in digital video storage, telecommunications and broadcasting.

One of the main features of MPEG-2 is that it accommodates existing television picture formats. The cable, satellite and terrestrial television broadcasting industries have shown a keen interest in the development of MPEG-2.

MPEG-2 is designed to operate for higher quality pictures than was intended for MPEG-1 and can operate at higher bit rates. The higher the quality of picture desired at the receiver, the higher will be the required bit rate. To produce video quality similar to that achieved by conventional television, MPEG-2 is specified to operate with a bit rate in the range of 4 to 10 million bits per second. For the high definition picture formats being considered in the USA at present, MPEG-2 is defined to operate at bit rates of about 20 million bits per second.

In November 1993 an MPEG meeting in Seoul, Korea, finalised the technical details for MPEG-2 to reach the 'committee draft' stage (refer to Figure 2). It is expected that MPEG-2 will be released as a 'draft international standard' in March 1994 and then finally as an 'international standard' in November 1994.

The MPEG-2 standard is not a single fixed way of compressing a video signal, but rather it is a 'tool kit' of digital compression techniques. It is not necessary to use all these techniques in one MPEG system. Within broad constraints, it is possible to mix and match the various compression methods to build an MPEG-2 system that best suits a certain application. To standardise this process, different categories of MPEG-2 operation have been defined. In the MPEG-2 standard, these categories are defined by 'levels' and 'profiles' which set the parameters of operation.

The MPEG-2 standard is well suited to the introduction of high definition television (HDTV). HDTV offers a wider screen and a better picture quality than today's conventional television and can also deliver better accompanying sound.

Future Tasks of MPEG

As the work on MPEG-2 is drawing to completion, MPEG has begun work on a new standard called MPEG-4. This new standard is titled 'Very Low Bit rate Coding of Moving Pictures and Associated Audio'.

Many applications for MPEG-4 are being considered. One example is very low bit rate video for mobile videophones.

An MPEG-3 standard was to have been developed, especially to accommodate HDTV. However due to the success of MPEG-2 for HDTV picture formats, MPEG-3 became redundant.

During 1994, MPEG meetings are scheduled to be held in France, Norway and Singapore during March, July and November respectively.

Uses of MPEG

MPEG standards will have an impact on the delivery of all future digital video services. Satellite pay television in Australia, for example, is required to use a digital system and will most likely opt for a MPEG compatible alternative. In North America, satellite television services based on the MPEG-2 standard will soon commence operation. European satellite television broadcasters are working on a committee called the European Launching Group for Digital Video Broadcasting which is also moving towards adopting MPEG standards.

Those interested in digital terrestrial television are also keen to see MPEG-2 commonly accepted. The US Grand Alliance, a consortium of companies involved in HDTV, has agreed to use MPEG-2 video standards. To study options for the introduction of digital terrestrial television broadcasting (DTTB) in Australia, the ABA, in June 1993, established a DTTB Specialist Group. Amongst other tasks, the Specialist Group is assessing the implications of adopting MPEG standards for Australia.

MPEG decoders have already been built by leading electronic manufacturers. In the case of digital television, it is most likely that the MPEG products that consumers will first see are set top converters or 'black boxes' that will convert incoming digital signals into signals that a conventional television set can handle. Recorded video on compact discs using MPEG standards, commonly known as CD-I, will also soon become available.

Conclusion

MPEG is a joint ISO/IEC study group that is developing standards for digital video and audio compression. Digital video and audio can deliver better quality services but digital compression is required to reduce the total bit rate and therefore the amount of spectrum needed. Transmission and distribution of digital video is easier and more efficient at lower bit rates.

MPEG standards MPEG-1 and MPEG-2 are likely to be accepted by those in the satellite, cable and terrestrial television broadcasting industries. The work of MPEG in formulating standards is crucial in coordinating the world wide introduction of digital television.

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First Report on the work of the Australian Broadcasting Authority Specialist Group on Digital Terrestrial Broadcasting

Australian Broadcasting Authority